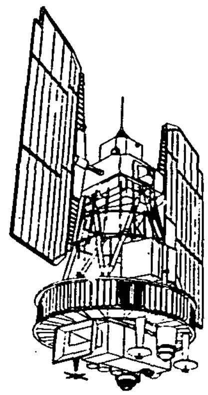
RELEASE NO: 74-329



FOR RELEASE JANUARY 14, 1975

PRESS KIT

ERTS-B

(Earth Resources Techology Satellite)

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D. C. 20546
202-755-8370

NEWS

FOR RELEASE:
TUESDAY,
January 14, 1975

RELEASE NO: 74-329

PROJECT: ERTS-B

PRESS KIT

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Washington, D. C. 20546
(Phone: 202/755-8370)

FOR RELEASE:
TUESDAY,
January 14, 1975

RELEASE NO: 74-329

NEW SATELLITE TO SURVEY NATURAL RESOURCES

New help from space in managing Earth's natural resources wisely and protecting its environment is promised by a picture-taking satellite that NASA is preparing to launch from California about Jan. 19.

The second Earth Resources Technology Satellite -- ERTS-B, to be designated ERTS-2 when in orbit -- will team up with ERTS-1, in operation since July 1972, to provide repetitive coverage of almost the entire globe.

"If I had to pick one spacecraft, one Space Age development to save the world," Dr. James C. Fletcher, NASA Administrator, said recently, "I would pick ERTS and the satellites which I believe will be evolved from it later in this decade."

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Data from ERTS-2 will be used by more than 100 research teams in federal, state and foreign governments, international organizations, universities and private companies for a broad range of Earth studies -- called the ERTS Follow-on Investigation Program -- in more than 40 states and more than 40 foreign countries.

In addition, NASA, in cooperation with federal and state agencies, will conduct a number of experimental demonstrations designed to show the practical benefits in resource management of multispectral remote sensing from space. These include experiments in water management, agriculture and land use planning.

One is a Large Area Crop Inventory Experiment (LACIE), a joint investigation with the U.S. Department of Agriculture and the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce. It is designed to test whether the use of data, gathered by spacecraft and analyzed with the aid of computers, can improve the timeliness and accuracy of major crop forecasts.

The experiment will combine crop acreage measurements obtained from ERTS data with meteorological information from NOAA satellites and from ground stations to relate weather conditions to yield assessment and ultimately to production forecasts.

The Department of Agriculture will study the experimentally derived production estimates for possible use in its crop reports, which are made public as a routine service to the domestic and international agricultural community.

At the outset LACIE will concentrate on wheat grown in North America. If this activity proves successful and useful the first year, it will be extended in the second year to other regions and ultimately to other crops.

Speaking before the U.N. World Food Conference in Rome last fall, Secretary of State Henry A. Kissinger called the experiment "a promising and potentially vital contribution to rational planning of global production."

Besides the Department of Agriculture and NOAA, user agencies working with NASA in the ERTS program include the Department of Interior, the Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers and a number of regional, state and local organizations.

ERTS-B is scheduled for launch by NASA from the Western Test Range near Lompoc, Calif., aboard a two-stage Delta rocket. It will be controlled from NASA's Goddard Space Flight Center, Greenbelt, Md., where the collected data initially will be processed.

The primary objective of the ERTS mission is the acquisition of multispectral repetitive data of the surface of the Earth in the form of imagery or in digital format on magnetic tape. Another objective is the development of a relay system to gather data from remote, widely distributed ground sensor platforms.

ERTS-1 data is providing new insight into man's continuing efforts to better manage the Earth's limited resources as well as aiding in the assessment and understanding of environmental changes. Areas in which this data is applicable include: agriculture, range resources, environment, forestry, geology, land use, marine resources, meteorology and water resources.

In its 29 months in orbit, ERTS-1 has returned more than 100,000 images, covering the entire U.S. and many other parts of the globe. It takes 18 days to complete a cycle over the whole Earth, beginning again on the 19th day. Analysis of these images by the world's scientific and technical community already has produced many beneficial results. These include:

Agriculture -- accurate estimates of the acreage of wheat, barley, corn and rice and determination of the growth status of crops at various times during the growing year;

-- evidence of how controlled grazing in the desert areas of the Sahelian region in Africa can lead to the reclamation of desert land for productive use;

Forestry -- accurate estimates of timber volume and of the extent and volume of timber taken through clear-cutting and other timber industry techniques for ecological management;

Land Use, Land Mapping -- up-to-date maps prepared in a matter of days compared to the months or years previously required;

-more-

-- development of thematic maps (maps portraying a particular subject). Previously unknown features in Antarctica have been identified, including a group of mountains in southern Victoria Land and at the head of Lambert Glacier;

Water Quality and Resources -- estimates of actual areas covered by water that are replacing previously used rough estimates;

-- before and after views of river flood areas which make it possible to ascertain quickly the areas covered by water for flood relief and flood control purposes;

-- accurate prediction and management of water runoff from snowmelt which provides a large portion of the usable water in the western U.S.;

Minerals and Land Resources -- identification of previously unknown Earth structural features, particularly long linear faults and fractures important for the detection of minerals and potential earthquake zones;

Marine Resources -- provision of synoptic views of coastal zones for predicting the dispersal of river-borne sediments and monitoring the dispersal and effects of dumping industrial wastes and sewage within the coastal zone for use as an aid in harbor planning -- to predict when channel dredging will have to be conducted;

Environment -- classification of strip-mined areas for estimation of mined acreage and reclaimed regions, monitoring of changes in protected wetlands areas due to construction and dredging and filling operations, and the detection of large-scale dumpings and outfalls in bodies of water.

ERTS-B carries the same complement of sensors as its predecessor. These include a return beam vidicon (RBV) camera subsystem, a multispectral scanner (MSS) subsystem and a data collection (DCS) subsystem. The RBV and the MSS provide independent images of the same 185-by-185-kilometer (115-by-115-mile) area of Earth in various spectral bands. The DCS collects and relays data from remotely located ground platforms to the ERTS data acquisition stations.

The 891-kilogram (1,165-pound) ERTS-B will be placed into a 920-km (570 mi.) circular, near polar orbit. Circling the globe every 103 minutes, the spacecraft's remote sensors will view a 185-km (115-mi.) wide strip of the Earth running nearly north-to-south at an angle to the equator of 99 degrees.

In this type of orbit, surface coverage of the Earth will proceed westward, with a slight overlap, such that the globe will be covered once every 18 days. The spacecraft's orbit is synchronous with the Sun. Thus ERTS-2 (like ERTS-1) will cross the equator at the same time (9:30 a.m. local time) every orbit. This consistent constant lighting of Earth, the best condition for the spacecraft's imaging systems.

Synoptic, repetitive coverage of Earth's surface under consistent observation conditions is required for maximum utility of the multispectral imagery to be collected by ERT-2.

Three NASA tracking and data acquisition facilities receive video information from ERTS. They are at Fairbanks, Alaska; Goldstone, Calif.; and Greenbelt, Md. In addition, Canada has a ground data acquisition station for ERTS at Prince Albert, Sask., and data processing facilities in Ottawa. Brazil has a receiving station at Cuiaba and processing facilities near Sao Paulo.

Italy and Iran are constructing similar facilities under agreements signed last year with NASA. Additional agreements are now being negotiated with other nations.

Data received from the satellite at the three U.S. data acquisition facilities will be sent to the NASA Data Processing Facility (NDPF) at Goddard. NDPF can handle some 1,300 scenes a week covering 45 million sq km (17 million sq. mi.).

Copies of all ERTS data and photos will be forwarded to the Department of Interior's Earth Resources Observation Systems (EROS) Data Center at Sioux Falls, S.D. On receipt at Sioux Falls the data are in the public domain and copies can be purchased by anyone. The Department of Commerce will also have data available at its National Oceanic and Atmospheric Administration (NOAA) Center at Suitland, Md., and the Department of Agriculture at its data products facility at Salt Lake City, Utah.

The overall ERTS program is the responsibility of NASA's Office of Applications, Washington, D.C.

Project management for the ERTS spacecraft, the Delta launch vehicle, the ground data handling system (GDHS), and the world-wide tracking network rests with the Goddard Space Flight Center, Greenbelt, Md.

Launching of the Delta is supervised by the Kennedy Space Center's unmanned launch operations team.

The Large Area Crop Inventory Experiment will be managed at the Johnson Space Center, Houston, Tex.

Prime contractor for the ERTS spacecraft, the data collection system aboard the spacecraft, and the ground data handling system at Goddard is the General Electric Co., Space Division, Valley Forge, Pa. Hughes Aircraft Co., Space and Communications Group, El Segundo, Calif., is prime contractor for the multi-spectral scanner; and RCA, Astro-Electronics Division, Princeton, N.J., is prime contractor for the return beam vidicon camera. RCA, Defense Communications Division, Camden, N.J., is the prime contractor for the wide-band video tape recorders. The McDonnell Douglas Astronautics Co., Huntington Beach, Calif., is prime contractor for the Delta launch vehicle.

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NASA costs for the ERTS program are about $197 million. This includes $112 million for two spacecraft and their instruments, $42 million for the data handling facility at Goddard and ground operations, $34 million for support of investigations, and about $9 million for two launch vehicles.

(END OF GENERAL RELEASE: BACKGROUND INFORMATION FOLLOWS.)

ERTS FOLLOW-ON INVESTIGATION PROGRAM

Exceptionally high-quality data returned from the ERTS-1 have demonstrated the feasibility of many potential applications in Earth resource management.

The initial steps of identifying, measuring and mapping Earth resources features are well documented with the ERTS-1 data. Extraction of useful information for management also has been achieved for many applications. Less has been accomplished, however, in monitoring changes in resources and environment with time. Efforts at prediction of change have been rare.

With ERTS-1 nearing the completion of its useful lifetime, the ERTS-2 will serve as a continuing source of data for the ERTS Follow-on Investigation Program. Preference was given in the selection of these investigations to those that demonstrate direct participation and cost-sharing with bona fide users, both in government agencies and industry. Direct comparison of ERTS data with those from conventional sources will be emphasized in terms of accuracy, validity, usefulness, costs and benefits. And all procedures in the selected investigations will be documented so that other users might test the proposed system under different conditions.

The ERTS Follow-on Investigations fall into eight scientific disciplines:

DISCIPLINE	NUMBER OF INVESTIGATIONS
Agriculture/Forestry/Range Resources	22
Land Use Survey and Mapping	26
Mineral Resources, Geological, Structural and Landform Surveys	20
Water Resources	13
Marine Resources and Ocean Surveys	9
Meteorology	4
Environment	11
Interpretation Techniques Development	4
TOTAL	109

Since a number of contracts and agreements are still being negotiated, the actual number of investigations finally approved may vary from the numbers listed above.

Agriculture

Several ERTS-1 investigations have demonstrated the usefulness of remotely sensed data in agricultural applications. Follow-on Investigations will extend the geographical areas covered and produce results that can be applied more generally. The United Nations Food and Agricultural Organization (FAO), for example, plans to use ERTS data to evaluate the available land resources and land degradation hazards like erosion, salinization and waterlogging for the entire continent of South America. Eventually, FAO in conjunction with the U.N.'s Educational, Scientific, and Cultural Organization (UNESCO) expects to prepare a soil map of the whole world at a uniform scale and legend.

Several investigations are involved in assessing agricultural resources in particular countries. Since these countries are frequently among the less developed, the ability of ERTS to provide data covering large areas at relatively low cost is especially important. Generalized studies of this nature are planned for Argentina, Lesotho, Kenya, Upper Volta and Niger. A similar study covering Nicaragua seeks to develop an agricultural information system that will serve as a prototype for all of Central America.

Crop identification and acreage estimation are involved in several investigations. Through the use of mathematical models, such data can lead to forecasts of production of various crops. Corn, soybeans, wheat and sorghum will be studied in Indiana, Illinois and Missouri, while winter wheat will be studied in Kansas and Oklahoma. Each investigation will seek to assess the accuracy of acreage estimation made with ERTS data and to develop techniques to use such data on a systematic and repetitive basis eventually for worldwide applications.

Some investigations are concerned explicitly with the temporal changes in vegetation that can be observed by ERTS. For example, the vernal advancement and recession of vegetation (the "green wave effect") will be monitored throughout the Great Plains of the central U.S. to help achieve optimum use of this very climate-dependent production area. Changes also will be measured in forest inventory and forest land classification to produce maps and statistical summaries of such changes in California. In the desert regions of southwestern U.S., livestock forage is based on ephemeral plants that are highly reactive to variation in the amount of precipitation. ERTS data will be used to develop a fast, efficient tool for determining forage production over large, complex areas. Grazing rotation and overall rangeland management are immediate applications for such a tool.

Water resources are centrally involved in other agricultural follow-on investigations. ERTS data will be used to study soil, water and vegetation conditions in southern Texas. The investigations will attempt to assess farm and ranchland flooding, analyze flood recession rates and economic impact, delineate productive and non-productive terrain, and monitor an impending erosion problem in Hidalgo County, Tex. The feasibility of using ERTS data to inventory and monitor California's irrigated lands also will be demonstrated. Agricultural lands of this state will be stratified, and the acreage of land by strata will be estimated for each county that receives irrigation service.

Land Use

Land use investigations are frequently concerned with resource study and assessment over large areas like states, regions, or even nations. Some of ERTS follow-on investigations in land use are very general in their topics, while others are directed more strongly along disciplinary lines like geology or hydrology. Many are multidisciplinary studies that are grouped with those in land use for convenience.

Several of the U.S. investigators are associated with state agencies and are conducting studies to classify land use, monitor changes, produce maps, and provide information for resource management. Such studies will take place in Nebraska, Minnesota, Mississippi and in east central Florida. ERTS data will be used for recreational land use planning, flood plain management, and strip mine reclamation monitoring in Ohio. And in Arkansas, land use change detection with ERTS data will be studied for the purpose of monitoring and predicting water quality degradation.

Cartographic applications are the primary goal of some investigations. ERTS imagery will be compared with source maps and large scale photography to evaluate the usefulness of ERTS data in determining the location and limits of areas of vegetation. Some of the novel techniques and procedures that have been developed for exploiting aerial photography in map making will be applied to ERTS imagery. Improved replication processes are expected to result from the study.

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Investigators in foreign countries will benefit greatly from the ERTS Follow-on Investigation Program. Many countries, particularly those that are developing, have large areas that are poorly known. ERTS imagery provides an unparalleled opportunity to map such areas, assess their land use and evaluate their present and potential capability for resource development. Studies of this nature are planned for Brazil, Peru and Venezuela in South America; Botswana and Zaire in Africa; and Iran, Thailand, and Vietnam, in Asia. In some cases, the training of personnel to make use of remotely sensed data is a stated goal of the investigation.

ERTS imagery will be used to produce thematic maps of the Leon Queretaro area of Mexico. In New Zealand ERTS imagery will be used to locate more exactly the widely scattered Kermadec Islands, as well as to conduct land use studies with an environmental bearing. An extensive land use study is planned for Korea where land classifications and changes will be assessed, and hydrological features like estuary flow dynamics and surface water distribution for flood forecasting will be analyzed.

Geology

Geology, like land use, can profit from the large area covered by a single ERTS image. Linear features can be detected that would pass unnoticed in other forms of imagery or photography. Many ERTS follow-on investigations will exploit this feature to study geological structures of various areas. The tectonic structure of Alaska will be studied by means of ERTS imagery to provide inputs to a tectonic model of that region.

The search for mineral resources is a stated major goal of most investigations in geology. States included in these investigations are: Colorado, Missouri, Montana, Nevada, New Mexico, Montana, Oklahoma, Utah and Wyoming. Similar studies are planned for Australia, Bolivia, Brazil, Colombia, Finland, Gabon, Buiena, Libya, Malaysia and Peru. Other Latin American countries are expected to be included at a later time.

ERTS imagery also will be used to prepare a geologic photo map and perform a hydrologic study of the Yemen Arab Republic. This investigation is typical of those conducted in the less developed countries. In New Zealand, on the other hand, a broad scope study is planned involving volcanic prediction, environmental and engineering planning, and earthquake zonal investigation, as well as mineral exploration, A series of studies in Turkey will apply ERTS imagery to copper ore detection, petroleum detection, dam monitoring, and other hydrological and agricultural tasks.

Landslides and avalanches are frequent hazards in mountainous regions. The application of ERTS imagery in defining such regions and providing adequate public warning of the hazards will be investigated. Landslide investigations in southern Italy will be performed, along with a study of ground and underground water, vegetative cover and slope gradient. Landslides and earthflows in the northern Appennines also will be studied.

Water Resources

A wide variety of applications in geographically diverse areas will be covered in the ERTS follow-on program in water resources within a relatively small number of investigations.

Some investigations are concerned primarily with general water resource inventorying, monitoring and management. Such studies are planned for South Dakota where remote sensing techniques are expected to provide inputs to operational models for management and planning.

Operational techniques also will be developed to inventory and monitor water resources and water uses in the Texas coastal zone. In Florida the distribution of water level dynamics will be studied and the outputs from a data collection system will be correlated in a general monitoring program for this seasonally restricted water supply.

Watershed runoff and flood retention are major topics of some investigations. For example, spectral measurement of watershed runoff coefficients in Oklahoma and Texas will be performed to provide inputs to models used in a flood retention program. Both ERTS imagery and a direct data link will be utilized for reservior management and operation in New England. The hydrologic aspects of snow also will be studied in New York, Minnesota and California. These include snowline elevation, snow cover and per cent melting.

Technology transfer is the primary goal of another investigation in water resources. ERTS and other supporting data will be used to familiarize local agencies in Arizona, New Mexico, Utah and California in the application of such data of their monitoring, management and planning functions.

Foreign investigations cover both the less developed and the more advanced countries. A broad program of hydrologic research is planned for the central delta of the Niger River in Mali. A comprehensive study also will be conducted in the lower Mekong River Basin in Thailand, Vietnam and Laos. Special attention will be given to mapping of forest cover, irrigible lands and flood and drainage patterns; development of models for salinity intrusion in the delta; and crop discrimination. In the northern regions of Pakistan, ERTS data will be used in snow surveys to monitor reservior inflow and the overall supply of irrigation water.

Seasonal variations in water resources will be studied in two European investigations. In Switzerland, a national resources inventory and land evaluation will be conducted, including climatic, hydrologic and biotic features. In Norway, ERTS data will be applied to studies of soil moisture, the ground water reservior for power production, snow reservoir measurement and springtime flood warning.

Marine Resources

The ERTS Follow-on Investigation Program in marine resources is another example of diverse coverage with a relatively small number of investigations. ERTS data will be applied to the management of Delaware's marine and wetland resources. This study will cover a broad range of topics: thematic mapping of coastal regions, mapping of ecological communities, predictive models for oil slick movement and sediment transport, and the dispersion of acid waste disposed off-shore.

On the California coast, ERTS data will be used to study nearshore processes like sediment transport, nearshore currents, river discharge and estuary flushing. Analytical and modeling results are anticipated that will reduce the required maintenance and the storm damage in coastal regions.

ERTS data will be used to investigate fishery resources in the Gulf of Mexico. The occurrence of thread herring will be correlated with remotely sensed water parameters to provide information on fish abundance and distribution, and to aid in the long term management of this valuable natural resource.

Shoreline form analysis will be the subject of another study. ERTS data will be used to monitor the Middle Atlantic coast, to observe temporal variations in the coastal features, and to determine the minimum types and amounts of data that must be collected to achieve these objectives.

With the increasing emphasis being placed on the development and utilization of Arctic oil resources, accurate and up-to-date knowledge of nearshore ice conditions is essential. Thus, ERTS imagery will be used to survey the ice along the northern and western coasts of Alaska and to produce maps that will predict the nearshore ice conditions in these regions.

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Ice studies are also planned by two Norwegian investigators. They will be concerned with the Spitsbergen-Greenland area, and will use ERTS imagery to forecast sea ice movements, track ice floes, and derive form and dimensional statistics for sea ice. A similar study will be performed for Antarctic regions. ERTS imagery will be used in this study to investigate mass balance, iceberg distribution and drift, and plankton production rates and distribution.

Ecology plays a major role in a study planned for the Baltic Sea. ERTS data, coordinated with extensive ground truth data, will be used to analyze the dynamics and energy flows in the Baltic Sea. Specific topics of study include phytoplankton blooms, horizontal transport of sediment and urban waste plumes.

Multidisciplinary studies of the French Atlantic Littoral Zone and the Massif Armoricain will be conducted. Investigation topics will include sediment plumes, mud movement with fluvial and tidal currents, littoral sedimentation, evolution of shorelines and estuaries, the geomorphology, hydrology, and pedology of coastal marshes, coastal land utilization, mineral resources and ground water resources.

Meteorology

Two of the ERTS Follow-on Investigations in meteorology are characterized by requiring imagery over large areas. Images will be collected for several states in the midwest to analyze mesoscale variations in the heat budget and the manifestation of these variations in the small scale cumuliform clouds that appear in ERTS imagery.

ERTS data covering the eastern United States and Canada also will be used to study cloud banding, particularly the physical processes that cause banding, and to determine the relations of other mesoscale cloud features to meteorological conditions.

The ERTS Data Collection System will be used in a weather modification program in the upper Colorado River Basin. Specifically, efforts will be made to develop procedures for other data users, and to compare the cost and quality of the data received. Investigation topics will include weather and avalanche forecasting, cloud seeding operations and streamflow forecasting and evaluation.

In England, ERTS imagery will be used in mesoscale assessments of clouds and rainfall. ERTS data will be compared to that obtainable from National Oceanic and Atmospheric Administration satellites, and rainfall prediction techniques will be studied.

Environment

The ERTS Follow-on Investigations in environment are frequently concerned with monitoring changes in the environment. Surface mining is a good example. ERTS data will aid in implementing the Pennsylvania Surface Mining Conservation and Reclamation Act. Such monitoring support is expected to evolve into a long-term operational control. A similar study will be conducted in Kentucky, where ERTS data will be used to monitor and inspect surface mining operations. Inspection strategies will be evaluated and cost-benefit analyses will be performed.

Water quality is primary in some environment investigations. Studies will evaluate the applications of ERTS data to water resources control in California and compare the value of ERTS data to that from other sources. Surveillance and control of eutrophication (rich in nutrients but becoming shallow, lacking oxygen) in the Great Lakes also will be studied.

ERTS data will be used to classify the lakes by trophic state and to analyze turbidity patterns in the lakes and land use categories in their watersheds. The effects of construction and stage filling of reservoirs on the environment in Missouri also will be investigated with the aid of ERTS.

ERTS data will be applied to natural resource protection and recreational development in West Virginia. The data will contribute to an inventory of recreational resources and will aid in their management and preservation. In Alaska, ERTS imagery will be used to identify and map wildlife habitats. And in North Dakota improved methodology for the inventory and classification of wetlands will be derived. ERTS data will aid in enumerating the wetlands, identifying their vegetative quality, and predicting their annual waterfowl production.

Atmospheric aerosol content will be the subject of another environmental study in southern California. Here, ERTS imagery will be analyzed to determine the aerosol content for urban and rural areas, and to derive empirical relationships for aerosol content, radiance and image contrast.

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In Japan, the usefulness of ERTS data in monitoring environmental change patterns will be assessed.

ERTS imagery also will be used to monitor fires in South Africa. The extent and temporal occurrence of the fires in various veld types will be analyzed and means of using ERTS imagery to apply correct management plans for rangelands will be studied.

Interpretation Techniques

The ERTS Follow-on Investigations in interpretation techniques generally have strong orientation toward other scientific disciplines. Land classification studies in Iowa, for example, will use enhanced ERTS images. An anticipated product is a series of color thematic maps to assist local and regional planners. Another investigation seeks to make significant improvements in the identification of crops in Kansas. Signatures derived from ERTS imagery will be corrected for atmospheric distortion, environmental distances, decay functions, sensor viewing conditions and location errors, then combined with crop calendar data in a comprehensive processing scheme.

Automatic change detection will be the subject of another study in interpretation techniques. ERTS data will be used in algorithms to improve the precision, efficiency, and flexibility of such detection. Classification of ground cover and land use in Alabama will be a result of the investigation.

THE SPACECRAFT

The ERTS-B design is similar to that of the ERTS-1 now in orbit. Both ERTS spacecraft are patterned after the highly successful Nimbus meteorological satellites developed for experimental purposes. Nimbus spacecraft regularly have returned meteorological data and pictures of the Earth's weather and surface since 1964. Nimbus achieved extremely precise, stable, spacecraft attitude control, a feature required by the ERTS in their role of high-resolution image collection.

The ERTS-B spacecraft consists of integrated subsystems that provide the power, thermal control, orbit maintenance, the sensor payloads for one year in orbit. It weighs approximately 953 kg (2,100 lbs.) and has an approximate overall height of 3.04m (10 ft.) and a diameter of 1.52m (5 ft.), with solar paddles extending out to a total of 3.96m (13 ft.). Attitude of the spacecraft is controlled with a pointing accuracy of less than 0.7 degrees in all three axes (roll, pitch and yaw). Two wideband video tape recorders store up to 30 minutes each of picture information for delayed readout when the spacecraft is in view of a data acquisition station.

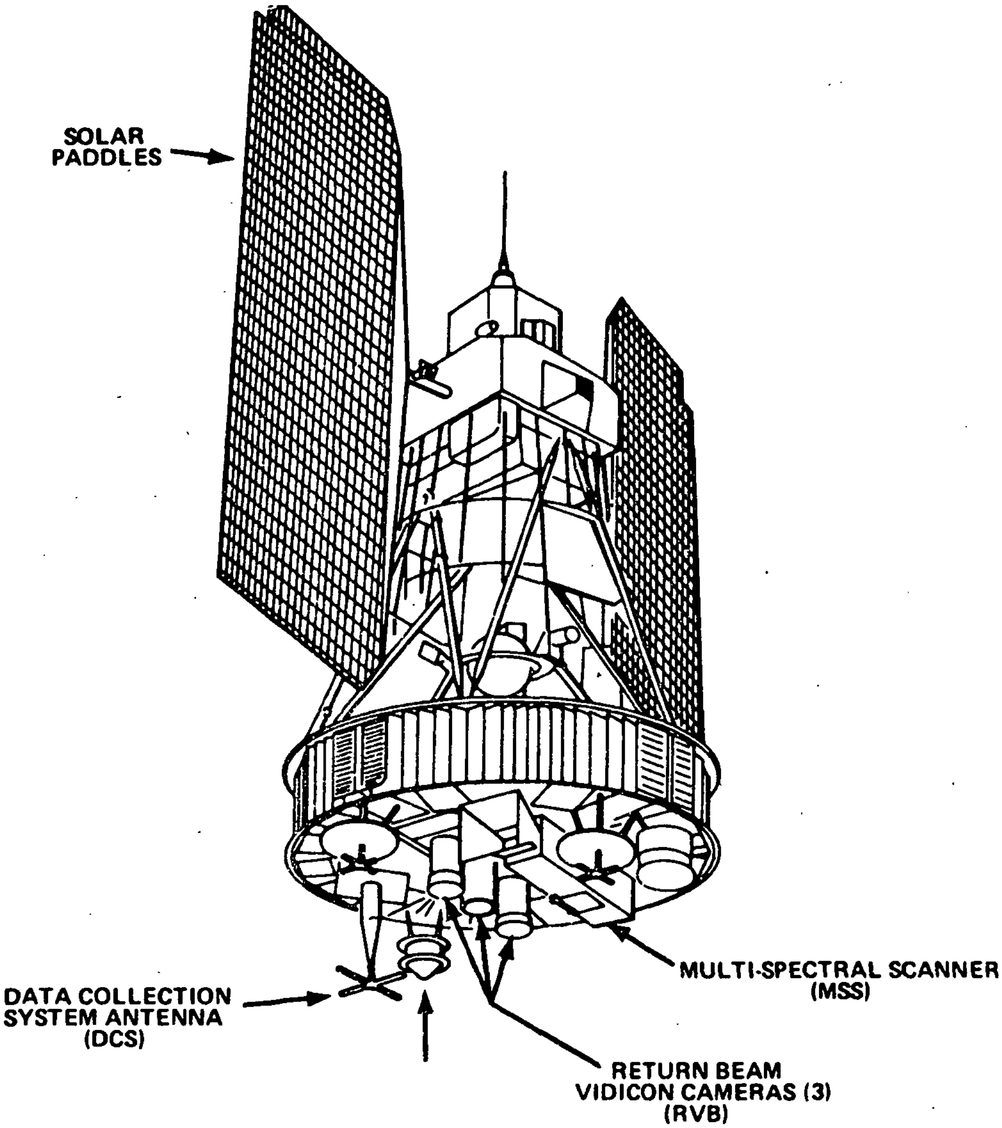
The Sensors

ERTS-B carries the same sensors as its predecessor. These include the return beam vidicon subsystem (RBV) and multispectral scanner subsystem (MSS) sensors and the data collection subsystem (DCS). The RBV and MSS provide independent images of the same 185 by 185 km (115 by 115 mi.) area of Earth in various spectral bands. The DCS collects and relays data from remotely located ground platforms to the ERTS data acquisition stations.

Return Beam Vidicon Subsystem

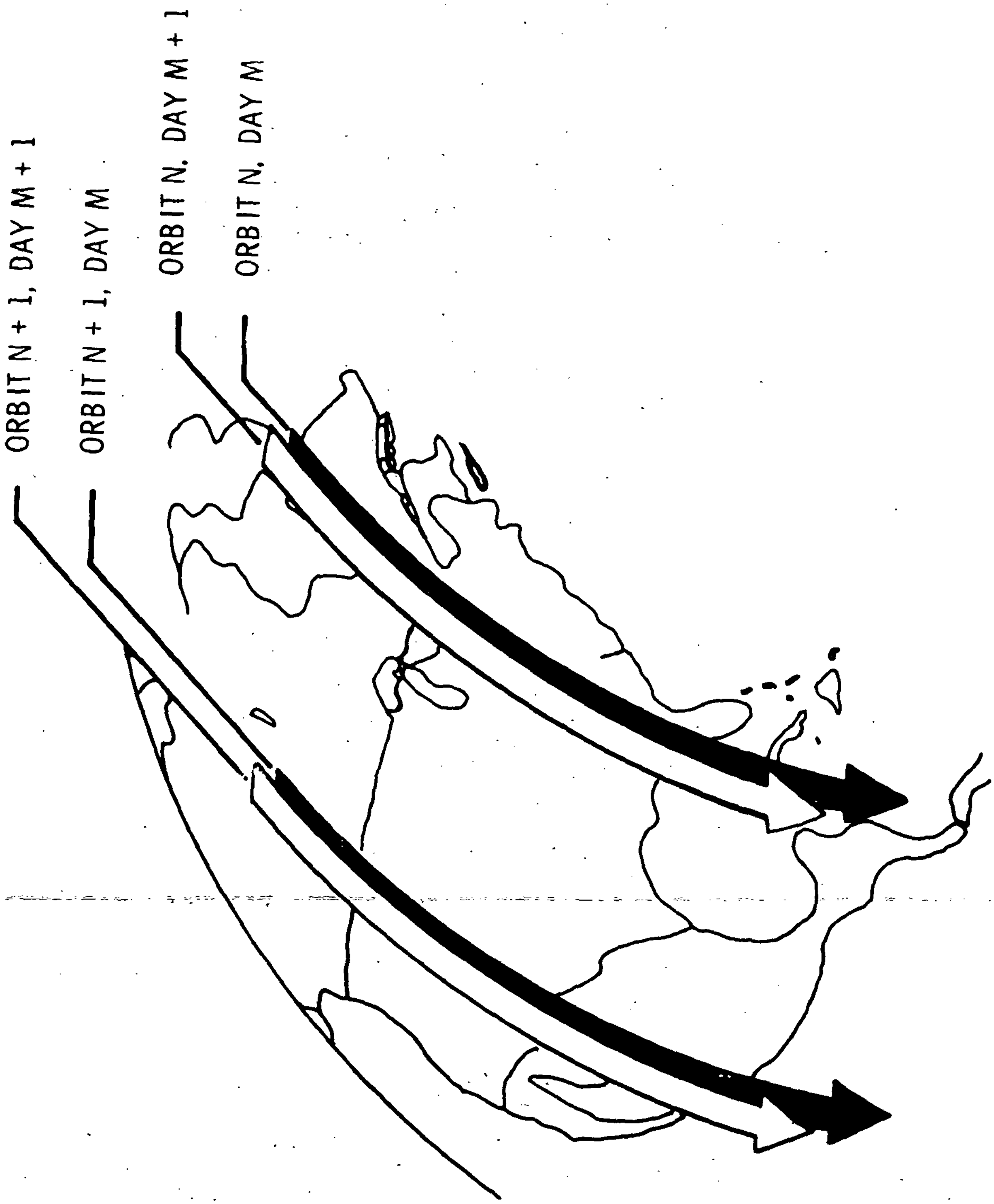
Three return beam vidicon (RBV) cameras view the same ground scene from the spacecraft as does the MSS but are sensitive to different spectral bands within the total band range from 0.475 to 0.83 micrometers. When the cameras are shuttered, images are stored on photosensitive surfaces within each vidicon camera tube; the tubes are then scanned to produce video outputs. The cameras scan in sequence, requiring about 3.5 sec. to read out each of the three images. To produce overlapping images of the ground along the direction of satellite motion, the cameras are reshuttered every 25 sec.

ERTS SPACECRAFT



ERTS

GROUND COVERAGE PATTERN



NASA G-71-5490

Images from each of the three RBV cameras contain information pertinent to the various areas under investigation. Full color images can be produced when each of the separate images is processed and superimposed in its respective color on a single frame.

Multispectral Scanner Subsystem

The multispectral scanner subsystem collects data by continually scanning the Earth directly beneath the ERTS spacecraft. The width of the strip is identical to that of the RBV cameras. Optical energy is sensed by an array of detectors simultaneously in four spectral bands ranging from 0.5 to 1.1 micrometers.

The scanning is achieved by means of a mechanically oscillating mirror that flips from side to side about 13 times a second as the spacecraft progresses southward or northward above Earth in its orbital path.

During ground processing, MSS images are produced that are equivalent in area to those produced with the RBV cameras.

Data Collection System

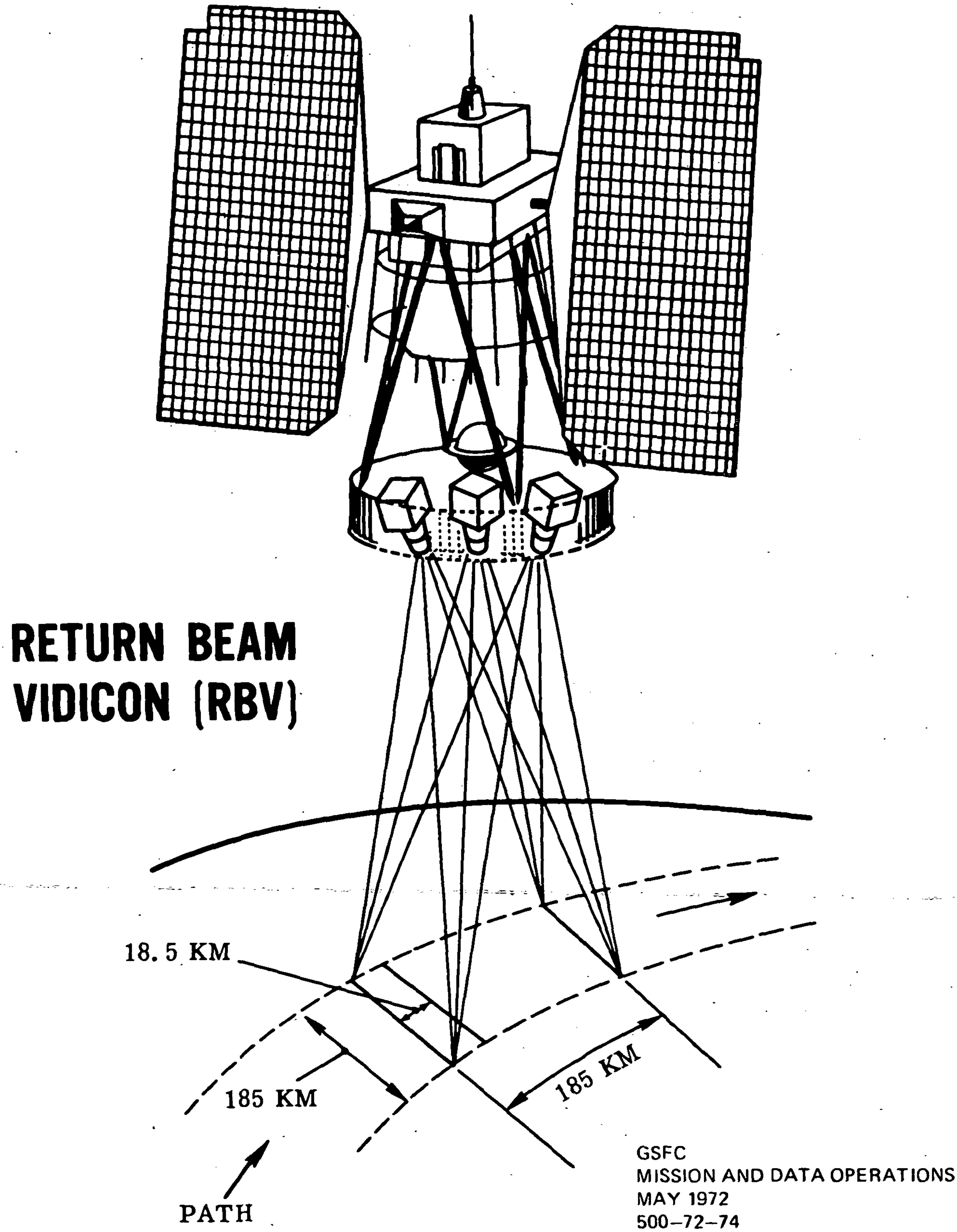
The data collection subsystem (DCS) aboard the ERTS-B will collect and relay data from up to 1,000 sensor-platforms, located in remote areas throughout the U.S., to the ERTS data acquisition stations. Data will be transmitted twice a day from each platform when the spacecraft is in simultaneous view of the transmitting platform and a data acquisition station.

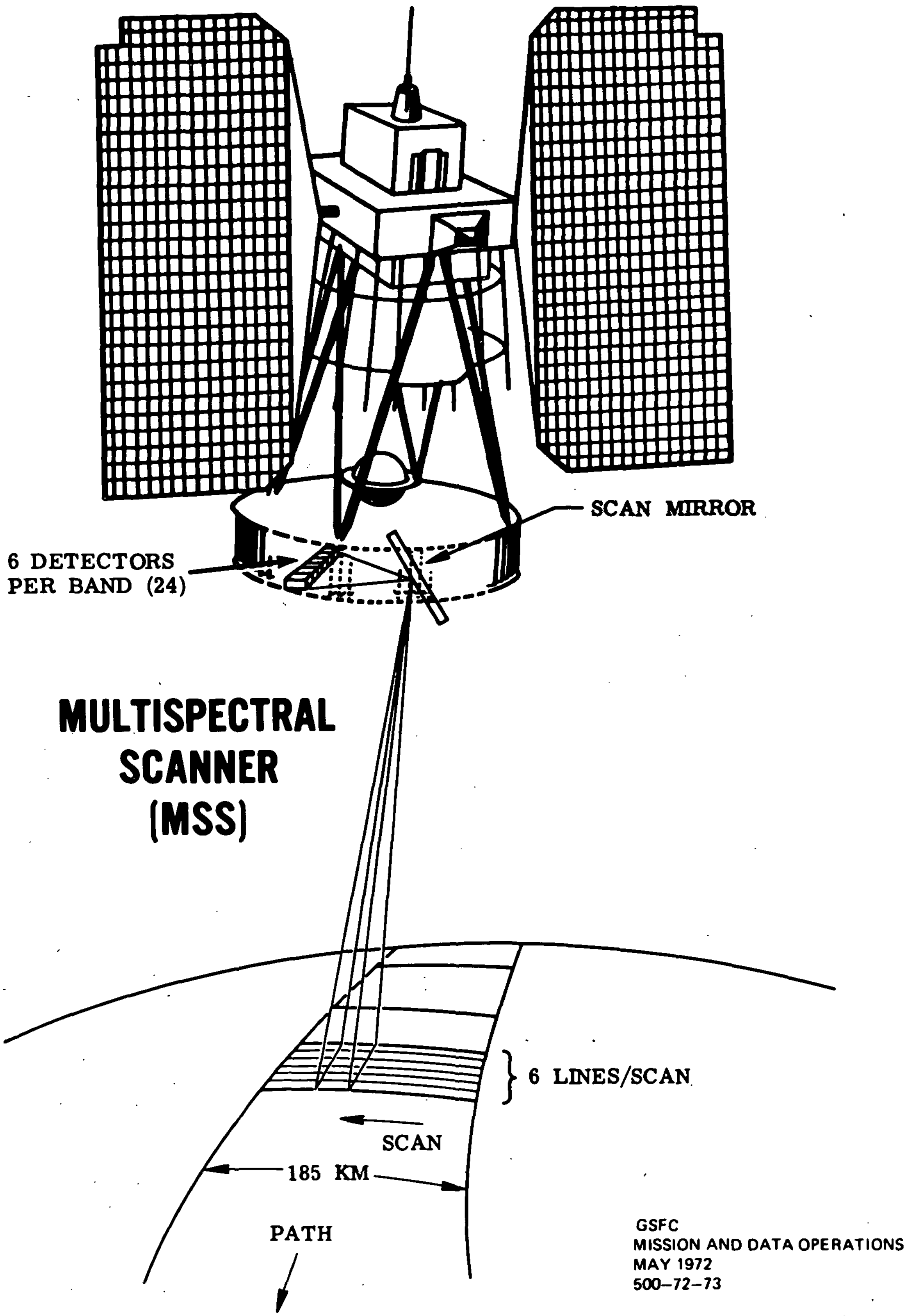
Each DCS platform collects data from as many as eight sensors, sampling such local environmental conditions as temperature, stream flow, snow depth, or soil moisture.

Data from all platforms ultimately will be relayed to the Goddard Space Flight Center and can be available to investigators within 24 hours after collection.

DELTA LAUNCH VEHICLE

ERTS-B will be launched by an improved two-stage Delta Launch Vehicle, managed for NASA by its Goddard Space Flight Center, Greenbelt, Md. The launch vehicle is Delta 107.


RETURN BEAM
VIDICON (RBV)
18.5 KM
185 KM
185 KM
PATH
GSFC
MISSION AND DATA OPERATIONS
MAY 1972
500-72-74


SCAN MIRROR
6 DETECTORS
PER BAND (24)
MULTISPECTRAL
SCANNER
(MSS)
6 LINES/SCAN
SCAN
185 KM
PATH
GSFC
MISSION AND DATA OPERATIONS
MAY 1972
500–72–73

To date, the Delta has launched 106 payloads and has a 90 per cent success record.

The 36 m (116 ft.) tall Delta consists of a liquid-fuel McDonnell Douglas Astronautics Co. extended-long-tank Thor booster, incorporating nine Thiokol strap-on Castor II solid-fuel rocket motors, and a TRW Corp. liquid-fuel second stage. Maximum girth of the 113,400 kg (250,000 lb.) Delta is 2.44 m (8 ft.) not including the strap-on motors.

An all-inertial guidance system, consisting of an inertial sensor package and digital guidance computer, controls the vehicle and sequence of operations from liftoff to spacecraft separation. A sensor package provides vehical attitude and acceleration information to the guidance computer, which generates vehicle steering commands to each stage. The system thus corrects trajectory deviations by comparing computed position and velocity against prestored values.

In addition the guidance computer performs the functions of timing and staging as well as issuing preprogrammed attitude rates during the coast phases.

LAUNCH OPERATIONS

NASA launch operations from its West Coast facility are conducted by the Kennedy Space Center's Unmanned Launch Operations Western Launch Operations Division (WLOD). This facility is located at Vandenberg Air Force Base, near Lompoc, Calif., approximately 125 miles northwest of Los Angeles and 280 miles south of San Francisco. Launch facilities are located on a promontory which juts into the Pacific Ocean near Point Arguello, making it possible to launch to the south to place payloads into polar orbit without overflying populated areas.

ERTS-B will be launched by Delta 107 from Space Launch Complex 2 West, which has been extensively updated over the years to accept the various Delta configurations, including the powerful new version now in use.

Most of the KSC personnel are on permanent assignment at WLOD, although a supplemental management and technical group from KSC in Florida assists during final preparations and the launch countdown.

Preparations for the launch of ERTS-B began October 22, 1974, with the arrival of the Delta first stage. Significant milestones since that date include first stage erection on the pad Nov. 27, installation of the nine solid strap-on rocket motors around the base of the first stage Dec. 2-4, inter-stage mating on Dec. 4 and second stage mating Dec. 6.

A "boilerplate" spacecraft was mated with Delta 107 and the payload fairing was installed Dec. 7, 1974. A series of tests conducted Dec. 8 included removal of the mobile service tower and spacecraft radio frequency line checks.

The flight spacecraft was scheduled to arrive at the Spacecraft Laboratory Dec. 30 to undergo prelaunch checks. The "boilerplate" spacecraft was to be removed and ERTS-B will be moved to the pad for mating with Delta 107 on Jan. 9, 1975.

SEQUENCE OF ORBIT EVENTS

Once in orbit, ERTS-B will be stabilized and oriented so the onboard sensors will best view the Earth directly beneath the spacecraft. During the initial orbits, systematic turn-on and checkout of the spacecraft sub-systems will be commanded from the ERTS operation control center (OCC) at Goddard. Simultaneously orbital information obtained from NASA's Space Tracking and Data Network (STDN), also managed and controlled by Goddard, will be used to determine the precise orbit.

Next, required orbital adjustments will be determined and executed by the ERTS OCC to establish the precise orbit for the systematic ground coverage by the spacecraft's sensors. With the initial orbital correction and checkout phase complete, ERTS-B - now designated ERTS-2 - will be commanded to begin its first year of normal operations.

Gross scheduling of the two sensors (RBV and MSS) will be performed in the operations control center for each 18-day cycle. More detailed operations will be planned for each forthcoming week, day and orbit. Realtime sensor operations will be commanded over the prime observation areas of the North American continent within direct view of one of the primary ERTS data acquisition stations located at Fairbanks, Alaska; Goldstone, Calif.; and Goddard.

PROGRAM OFFICIALS

NASA Headquarters, Washington, DC

Charles W. Mathews	Associate Administrator for Applications
Leonard Jaffe	Deputy Associate Administrator for Applications
William E. Stoney	Director, Earth Observations Program
James R. Morrison	Chief, Earth Resources Survey Program
Harry Mannheimer	ERTS Program Manager
Charles D. Centers	ERTS Program Engineer
Joseph B. Mahon	Director, Launch Vehicle and Propulsion Program
I.T. Gillam IV	Manager, Small Launch Vehicle and International Programs
P.T. Eaton	Delta Program Manager

Goddard Space Flight Center, Greenbelt, Md.

Dr. John F. Clark	Director
Robert N. Lindley	Director, Project Directorate
Jack Sargent	Project Manager
Dr. Stanley C. Freden	Project Scientist
Richard A. Devlin	Spacecraft Manager
Luis Gonzales	Mission Operations Director
James L. Michael	Mission Data Operations
Stephen F. O'Dea	Networks Director
Robert C. Baumann	Deputy Director of Projects for Delta

Kennedy Space Center, Fla.

Lee R. Scherer	Director
John J. Neilon	Director, Unmanned Launch Operations
Henry R. Van Goey	Manager, KSC, Western Launch Operations Div.
Wilmer "Bud" Thacker	Chief, Delta Operations, Launch Vehicle Engineering Branch
Gene Schlimmer	Chief, Spacecraft and Support Operations Branch
Gene Langenfeld	ERTS-B Spacecraft Coordinator
Norman Klitz	Chief, Facilities Support Branch

MAJOR CONTRACTORS

Company	Responsibility
General Electric Co.	Prime Contractor
Space Division	Spacecraft, Ground Data Handling
Valley Forge, Pa.	System, and Data Collection System

Company	Responsibility
Bendix Corp. Ann Arbor, Michigan	Ground Data Handling System Equipment
Wolf Research and Development Corp. Riverdale, Md.	Ground Data Handling System Equipment
Hughes Aircraft Co. Space and Communications Group El Segundo, Calif.	Multispectral Scanner*
RCA Astro Electronics Division Princeton, N.J.	Return Beam Vidicon* Power Subsystem Command Receivers
RCA Defense Communications Division Camden, N.J.	Wideband Tape Recorders*
McDonnell Douglas Astronautics Co. Huntington Beach, Calif.	Delta Launch Vehicle

* Government Furnished Equipment

DOMESTIC ERTS FOLLOW-ON INVESTIGATIONS

Test Site*	Principal Investigator	Investigation
ALASKA	Larry D. Gedney University of Alaska Fairbanks	Tectonic structure of Alaska as evidenced by ERTS imagery and ongoing seismicity
	William J. Stringer University of Alaska	ERTS survey of near-shore ice conditions along the Arctic Coast of Alaska
	Peter C. Lent University of Alaska	Use of ERTS imagery for wildlife habitant mapping in northeast and east-central Alaska
ARIZONA	G. Russell Bentley Bureau of Land Management Denver	Feasibility of monitoring growth of ephemeral and perennial range forage plants and effects of grazing management
	Larry K. Lepley University of Arizona Tucson	ERTS-B and supporting data for technology transfer to local agencies
ARKANSAS	Harold C. MacDonald University of Arkansas Fayetteville	Land use change detection with ERTS-B data for monitoring and predicting regional water quality degradation

*Where investigations have multiple test sites, they are included under more than one state.

Test Site	Principal Investigator	Investigation
CALIFORNIA	Robert N. Colwell University of California Berkeley	A statewide inventory of California's irrigated lands based on ERTS-B and supporting aircraft data
	A. Earl Davis State of California Sacramento	Water resources control investigation in California
	Douglas M. Pirie U.S. Army Corps of Engineers San Francisco	California coast nearshore processes study using ERTS-B data
	Donald R. Wiesnet National Oceanic & Atmospheric Administration Washington, DC	Evaluation of ERTS-B data for selected hydrologic applications
COLORADO	Kenneth L. Cook University of Utah Salt Lake City	Remote sensing in mineral exploration from ERTS imagery
	Paula V. Krebs University of Colorado Boulder	Multiple resource evaluation of Region 2 U.S. Forest Service lands utilizing ERTS multispectral scanner data
	Claude D. Peters State of Colorado Denver	Application of ERTS data to delimitation of avalanche and landslide hazards in Colorado

Test Site	Principal Investigator	Investigation
CONNECTICUT	Saul Cooper U.S. Army Corps of Engineers Waltham, MA	Use of ERTS and Data Collection System imagery in reservoir management and operation
DELAWARE	Robert Dolan University of Virginia Charlottesville	Application of remote sensing to shoreline form analysis
	Vytautas Klemas University of Delaware Newark, DE	Application of ERTS-B to the management of Delaware's marine and wetland resources
FLORIDA	John W. Hannah Brevard County Development Administration Titusville, FL	Regional planning in east central Florida
	Aaron L. Higer U.S. Geological Survey Miami	Subtropical water-level dynamics distribution
GEORGIA	Robert C. Heller U.S. Dept. of Agriculture Forest Service Berkeley, CA	Monitoring forest and range resources with ERTS-B and supporting aircraft imagery

Test Site	Principal Investigator	Investigation
ILLINOIS	Marvin E. Bauer Purdue University West Lafayette, IN	Crop identification and acreage estimation over a large geographic area using ERTS multispectral scanner data
	Ravinder K. Jain U.S. Army Corps of Engineers Champaign, IL	Investigation of the effects of construction and stage filling of reservoirs on the environment and ecology
INDIANA	Marvin E. Bauer Purdue University West Lafayette, IN	Crop identification and acreage estimation over a large geographic area using ERTS multispectral scanner data
IOWA	James V. Taranik Iowa Geological Survey Iowa City	Land classification of south-central Iowa from computer enhanced images
KANSAS	Marvin E. Bauer Purdue University West Lafayette, IN	Crop identification and acreage estimation over a large geographic area using ERTS multispectral scanner data
	Robert M. Haralick University of Kansas Lawrence	A comprehensive data processing plan for crop calendar multispectral scanner signature development from satellite imagery

Test Site	Principal Investigator	Investigation
KANSAS (cont'd.)	Richard F. Nalepka ERIM Ann Arbor, MI	Proposal to make wheat production forecasts using ERTS and aircraft remote sensing data
	John W. Rouse Texas A&M University College Station, TX	Regional monitoring of the vernal advancement and retrogradation of national vegetation in the Great Plains corridor
KENTUCKY	Robert E. Nickel State of Kentucky Frankfort	A feasibility analysis of the employment of satellite data to monitor and inspect surface mining operations
LOUISIANA	William H. Stevenson National Marine Fisheries Service, NOAA Bay St. Louis, MS	ERTS-B/Gulf of Mexico thread herring resource investigation
MAINE	Saul Cooper U.S. Army Corps of Engineers Waltham, MA	The use of ERTS and Data Collection System imagery in reservoir management and operation
MARYLAND	Robert Dolan University of Virginia Charlottesville	Application of remote sensing to shoreline form anaylsis

Test Site	Principal Investigator	Investigation
MASSACHUSETTS	*Saul Cooper* U.S. Army Corps of Engineers Waltham, MA	*The use of ERTS and Data Collection* System imagery in reservoir management and operation
MICHIGAN	Robert H. Rogers Bendix Aerospace Systems Division Ann Arbor, MI	Application of ERTS to surveillance and control of lake eutrophication in the Great Lakes Basin
MINNESOTA	Robert H. Rogers Bendix Aerospace Systems Division Ann Arbor, MI	Application of ERTS to surveillance and control of lake eutrophication in the Great Lakes Basin
	Joseph E. Sizer State of Minnesota St. Paul	ERTS-B applications to Minnesota resource management
	Donald R. Wiesnet National Oceanic & Atmospheric Administration Washington, DC	Evaluation of ERTS-B data for selected hydrologic applications
MISSISSIPPI	Preston T. Bankston State of Mississippi Jackson	Application and evaluation of ERTS data and automatic data processing techniques for land use and resource management

Test Site	Principal Investigator	Investigation
MISSISSIPPI (cont'd.)	William H. Stevenson National Marine Fisheries Service, NOAA Bay St. Louis, MS	ERTS-B/Gulf of Mexico thread herring resource investigation
MISSOURI	Marvin E. Bauer Purdue University West Lafayette, IN	Crop identification and acreage estimation over a large geographic area using ERTS multispectral scanner data
	Ravinder K. Jain U.S. Army Corps of Engineers Champaign, IL	Investigation of the effects of construction and stage filling of reservoirs on the environment and ecology
	James A. Martin Missouri Geological Survey Rolla, MO	Structural and ground pattern analysis of Missouri and the Ozark dome using ERTS-B satellite imagery
MONTANA	Terrence J. Donovan U.S. Geological Survey Denver	Study of alteration aureoles in surface rocks overlying
NEBRASKA	Marvin P. Carlson University of Nebraska Lincoln	Application of ERTS-B imagery in land use inventory and classification in Nebraska
	John W. Rouse Texas A&M University College Station, TX	Regional monitoring of the vernal advancement and retrogradation of national vegetation in the Great Plains corridor

Test Site	Principal Investigator	Investigation
NEVADA	Kenneth L. Cook University of Utah Salt Lake City	Remote sensing in mineral exploration from ERTS imagery
	Lawrence C. Rowan U.S. Geological Survey Denver	Detection and mapping of mineralized area and lithologic variations using computer enhanced multispectral scanner images
NEW HAMPSHIRE	Saul Cooper U.S. Army Corps of Engineers Waltham, MA	The use of ERTS and Data Collection System imagery in reservoir management and operation
NEW MEXICO	Karl Vonder Linden State of New Mexico Socorro, NM	Earth Resources evaluation for New Mexico by ERTS-B
NEW YORK	Donald R. Wiesnet National Oceanic & Atmospheric Administration Washington, DC	Evaluation of ERTS-B data for selected hydrologic applications
NORTH CAROLINA	Robert Dolan University of Virginia Charlottesville	Application of remote sensing to shoreline form analysis
NORTH DAKOTA	David S. Gilmer Bureau of Sport Fishing and Wildlife U.S. Dept. of Interior Jamestown, ND	Improving methodology for inventory and classification of wetlands

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Test Site	Principal Investigator	Investigation
NORTH DAKOTA (cont'd.)	John W. Rouse Texas A&M University College Station, Tx	Regional monitoring of the vernal advancement and retrogradation of national vegetation in the Great Plains corridor
OHIO	David C. Sweet Ohio Department of Economic & Community Development Columbus	Development of a multidisciplinary ERTS user program in the State of Ohio
OKLAHOMA	Bruce J. Blanchard U.S. Dept. of Agriculture Chickasha, OK	Spectral measurement of watershed runoff coefficients in the southern Great Plains
	Richard F. Nalepka ERIM Ann Arbor, MI	Proposal to make wheat production forecasts using ERTS and aircraft remote sensing data
	John W. Rouse Texas A&M University College Station, TX	Regional monitoring of the vernal advancement and retrogradation of national vegetation in the Great Plains corridor
OREGON	G. Russell Bentley Bureau of Land Management Denver	Feasibility of monitoring growth of ephemeral and perennial range forage plans and effects of grazing management

Test Site	Principal Investigator	Investigation
PENNSYLVANIA	Daniel J. Deely Earth Satellite Corporation Washington, DC	Implementation of the Pennsylvania surface mining conservation and reclamation act through ERTS-B support
RHODE ISLAND	Saul Cooper U.S. Army Corps of Engineers Waltham, MA	The use of ERTS and Data Collection System imagery in reservoir management operations
SOUTH DAKOTA	John W. Rouse Texas A&M University College Station, TX	Regional monitoring of the vernal advancement and retrogradation of national vegetation in the Great Plains corridor
	Fred A. Schmer South Dakota State University Brookings, SD	Investigation of remote sensing techniques as inputs to operational models
TEXAS	Bob Armstrong General Land Office State of Texas Austin	Development and application of operational techniques to inventory and monitor resources and uses in Texas coastal zone
	Bruce J. Blanchard U.S. Dept. of Agriculture Chickasha, OK	Spectral measurement of watershed runoff coefficients in the southern Great Plains
	John W. Rouse Texas A&M University College Station, TX	Regional monitoring of the vernal advancement and retrogradation of national vegetation in the Great Plains corridor

Test Site	Principal Investigator	Investigation
TEXAS (cont'd.)	Craig L. Wiegand U.S. Dept. of Agriculture Weslaco, TX	Soil, water, and vegetation conditions in south Texas
UTAH	Kenneth L. Cook University of Utah Salt Lake City	Remote sensing in mineral exploration from ERTS imagery
	Lawrence C. Rowan U.S. Geological Survey Denver	Detection and mapping of mineralized areas and lithologic variations using computer enhanced multispectral scanner images
VERMONT	Saul Cooper U.S. Army Corps of Engineers Waltham, MA	The use of ERTS and Data Collection System imagery in reservoir management and operation
VIRGINIA	Robert Dolan University of Virginia Charlottesville	Application of remote sensing to shoreline form analysis
WEST VIRGINIA	Ira S. Latimer Dept. of Natural Resources State of West Virginia Charleston	Contribution of ERTS-B to natural resource protection and recreational development in West Virginia
WISCONSIN	Robert H. Rogers Bendix Aerospace Systems Division Ann Arbor, MI	Application of ERTS to surveillance and control of lake eutrophication in the Great Lakes Basin

Test Site	Principal Investigator	Investigation
WYOMING	Terrence J. Donovan U.S. Geological Survey Denver	Study of alteration aureoles in surface rocks overlying
	Paula V. Krebs University of Colorado Boulder	Multiple resource evaluation of Region 2 U.S. Forest Service lands utilizing ERTS multispectral scanner data

DOMESTIC ERTS FOLLOW-ON INVESTIGATIONS USING FOREIGN TEST SITES (TENTATIVE)

Test Site	Principal Investigator	Investigation
NICARAGUA	Donald H. Von Steen U.S. Dept. of Agriculture Washington, DC	Area sampling frame construction for an agricultural information system with ERTS-B data
SOUTH AMERICA	William D. Carter U.S. Geological Survey Washington, DC	Evaluation of ERTS-B images applied to geologic structures of South America
YEMEN	David F. Davidson U.S. Geological Survey Washington, DC	Preparation of a geologic photo map and hydrologic study of the Yemen Arab Republic
ENGLAND	Froelich Rainey University of Pennsylvania Philadelphia, PA	Detection of crop mark contrast for archaeological surveys

DOMESTIC ERTS FOLLOW-ON INVESTIGATIONS NOT DIRECTLY RELATED TO SPECIFIC TEST SITES

Principal Investigator	Investigation
Robert E. Cummings NASA Marshall Space Flight Center Huntsville, AL	Automatic change detection of ERTS-B data
Michael Griggs Science Applications, Inc. La Jolla, CA	Determination of the atmospheric aerosol content from ERTS-B data
Archie M. Kahan U.S. Bureau of Reclamation Denver, CO	Use of the ERTS-B Data Collection System in the upper Colorado River basin weather modification program
Hugh B. Loving U.S. Geological Survey McLean, VA	Processing of ERTS imagery for dissemination purposes
Earl S. Merritt Earth Satellite Corporation Washington, DC	Study of mesoscale exchange processes utilizing ERTS-B air mass cloud imagery
Paul E. Scherr Environmental Research & Technology, Inc. Lexington, MA	Investigation to use ERTS-B data to study cumulus cloud banding and other mososcale cloud features
Joe F. Wilson National Oceanic & Atmospheric Administration Rockville, MD	ERTS-B imagery as a data source for producing vegetation overlay information on visual aeronautical charts

FOREIGN ERTS FOLLOW-ON INVESTIGATIONS

Country and Principal Investigator	INVESTIGATION
AUSTRALIA	
N. H. Fisher Bureau of Mineral Resources Canberra Co-I's: Leonard G. Turner Div. of National Mapping PB 667 Canberra Raymond L. Whitmore Dept. of Mining & Metallurgical Eng. Univ. of Queensland St. Lucia John S. Gerney Engineering & Water Supply Dept. Adelaide SA Hilary Harrington Div. of Mineral Physics CSIRO, North Ryde NSW Anthony D. Hooper Dept. of Northern Territory Darwin NT	Survey of capeweed distribution in Australia; Daly Basin development monitoring; study of structures in granitic bathyliths and associated fold belts in relation to mineral resources; water utilization-evapo-transportation and soil moisture monitoring in the south eastern region of South Australia; assessment of beach sand mining operations; mapping islands, reefs, and shoals in the oceans surrounding Australia; terrain analysis in western Queensland and Australia.
BOLIVIA	
Carlos E. Brockman Servicio Geologico de Bolivia La Paz	ERTS data investigation towards mineral resources development and land use survey.
BOTSWANA	
William L. Dickson Dept. of Surveys and Lands Gaborone	Evaluation of ERTS-B imagery as an aid to the development of Botswana's resources.

BRAZIL

Fernando de Mendonca
Instituto de Perguisas
Espaciais
San Jose dos Campos
Co-I:
L. H. A. Azevedo
Sensora Ltda. rua Urbano
Santos
no. 20 Urca

Applications of satellite imagery for natural resources survey of Brazilian territory; analysis of Earth Resources and factors governing environmental quality in Septentridnal, Brazil.

CENTO

J. A. Snellgrove
Central Treaty Organization
Ankara, Turkey

Regional investigations of tectonic and igneous geology in Iran, Pakistan, and Turkey.

FAO

J. A. Howard
United Nations Food and
Agriculture Organization
Rome

Application of ERTS imagery to the FAO/UNESCO soil map of the world; monitoring of high forest cover in Nigeria

FINLAND

Heikki V. Tuominen
University of Helsinki
Helsinki

Investigation of ERTS-B imagery on correlations between ore deposits and major shield structures in Finland

FRANCE

Fernand H. Verger
Ecole Pratique des Hautes
Etudes
Paris

Multidisciplinary studies of the French Atlantic littoral and the Massif Armoricain

GABON

Serge Gassita
Ministry of Mines
Libreville

Mapping and developing Gabon's natural resources

GUINEA

Ibrahima Soumah
Bureau of Mines and Geology
Conarky

Mineral and other natural resources investigations in Guinea

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IRAN

Khosro Ebtehadj Plan and Budget Organization Tehran	Utilization of ERTS data for resource management in Iran

ITALY

Carlo M. Marino University of Milan Milan	Geomorphic and landform survey of northern Appennini
Luigi G. Napolitano University of Naples Naples	Landslides investigation in southern Italy
Bruno Ratti Telespazio S.P.A. Rome	Terra Experiment--Techniques for collecting and processing Earth Resources data

JAPAN

Takakazu Maruyasu University of Tokyo Tokyo	Investigation of environmental change pattern in Japan

KENYA

Joab Omino Ministry of Natural Resources Nairobi	The development of methods for quantifying multispectral satellite images for use in rangeland habitat

KOREA

Jae Hwa Choi National Construction Research Institute Seoul	Land use survey and mapping and water resources investigations in Korea

LESOTHO

A. A. Jackson University of Botswano, Lesotho and Swaziland Roma	Natural resources research and development in Lesotho using ERTS imagery

LIBYA

Muftah M. Unis Ministry of Planning Tripoli	Comparison between geophysical prospecting and satellite remote sensing in south Libya.

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LIPTAKO-GOURMA AUTHORITY

C. Matthew Samake Liptako-Gourma Authority Ouagadougou, Upper Volta	**Earth Resources inventory and assessment of Upper Volta and Niger**

MALAYSIA

S. K. Chung Geological Survey of Malaysia Ipoh	**Geological and hydrological investigations in west Malaysia**

MALI

Bakary Toure Director General Geologie et des Mines du Mali B. P. 223, Bamako, Mali	**Hydrologic research using ERTS-B data for the central delta of the Niger River**

MEKONG

Willem J. Van der Oord Mekong Committee Bangkok, Thailand	**Agricultural and hydrological investigations for water resource development planning in the lower Mekong Basin**

MEXICO

Jorge F. Vaca Comision de Estudios del teritorio Nacional Mexico, D. F.	**Comprehensive study of Leon-Queretaro area**

NEW ZEALAND

M. C. Probine Physics and Energy Lab. DSIR, Lower Hutt Co-I's: M. G. Mcgreevy New Zealand Forest Service Private Bag, Rotorua I. F. Stirling Dept. Lands and Surveys Wellington Richard P. Suggate New Zealand Geological Survey Lower Hutt	**Seismotectonic, structural, volcanologic, and geomorphic study of New Zealand; indigenous forest assessment in New Zealand; mapping, land use, and environmental studies in New Zealand.**

NORWAY

Helge A. Odegaard NVE--Statskraftverkene Oslo	Hydrological investigations in Norway
Olav Orheim Norsk Polarinstitutt Oslo	Glaciological and marine biological studies at permimeter of Dronning Maud Land, Antarctica
Torgne E. Vinje Norsk Polarinstitutt Oslo	Sea ice studies in the Spitsbergen Greenland area

PAKISTAN

Chaudari Umar Pakistan Water and Soils Investigations Division Lahore	Water resources investigation in West Pakistan with help of ERTS imagery--snow surveys.

PERU

Jose C. Pomalaya Instituto Geofisico del Peru Lima	Application of remote sensing techniques for the study and evaluation of natural resources

SOUTH AFRICA

Denzil Edwards Botanical Research Institute Pretoria	Monitor fire extent and occurrence in the different veld types of South Africa with reference to ecology and range management

SWEDEN

Bengt-Owe Jansson University of Stockholm Stockholm	Dynamics and energy flows in the Baltic ecosystems

SWITZERLAND

Harold Haefner University of Zurich Zurich	National resources inventory and land evaluation in Switzerland.

THAILAND

Sanga Sabhasri National Resources Board Bangkok	Thailand national program of the Earth Resources Technology Satellite

TURKEY

Sadrettin Alpan Mineral Research and Exploration Institute (MTAE) Ankara Co-I's: Tuncer Iplikci Etibank Nihal Atuk Turkish State Water Works Dr. Altan Gumus Karadeniz Technical Univ.	National project for the evaluation of ERTS imagery applications to various Earth Resources problems of Turkey

UNITED KINGDOM

Eric C. Barrett University of Bristol Bristol	Mesoscale assessment of cloud and rainfall over southwest England

VENEZEULA

Alberto Enriquez Ministerio de Obras Publicas Caracas Co-I: Adolfo C. Romero Cartografia Nacional Caracas	Application of ERTS data to regional planning and environmental assessment in northern Venezuela; development of techniques for regional-ecological studies and technology for thematic mapping of a large and unknown area

SOUTH VIETNAM

Nguyen Duc Cuong Ministry of Commerce and Industry Saigon	Comparative evaluation of ERTS imagery for resources inventory and scientific research in Vietnam

ZAIRE

Kasongo Ilunga Sendwe Bureau du President Kinshasa	Participation of the Office of the President, Republic of Zaire, in the ERTS and Skylab projects

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ERTS-1 RESULTS

The data returned from ERTS-1 have proven to be of exceptional quality. Some of the practical applications that have been identified from ERTS-1 investigations are summarized in the following paragraphs.

Agriculture, Forestry and Range Resources

One of the important requirements of the agricultural sector of our economy is an accurate estimate of the production of certain commodities (e.g., wheat, barley, corn and rice) at various times during the year. Investigation results indicate that use of ERTS-1 technology can make sampling methods more efficient and provide better estimates of crop production.

An example of the use of ERTS-1 to improve sampling efficiency is illustrated in a study of San Joaquin County, Calif. Seventeen different agricultural classes were delineated in approximately 30 minutes on a single ERTS-1 image of the central valley of California, taken on July 27, 1972. The resultant delineation of classes was more detailed and up to date then that obtained through conventional methods used for crop inventory work. Thus, classification maps of the type provided by an analysis of ERTS-1 data will allow an optimal allocation of ground samples between the various classes, leading to improvements in the estimates of crops.

A more difficult, but equally successful, application of ERTS-1 technology is the estimation of crop acreage. For example, in Kansas estimates of wheat acreage made from ERTS-1 imagery were 99 per cent accurate. In this interesting case, knowledge of the crop calendar of the test area and the repetitive coverage provided by ERTS-1 allowed the investigator to pick the optimum time of the year to estimate wheat acreage -- a period in the fall when wheat was not present, but the presence of fallow ground correlated highly with wheat planting.

Similar results were obtained in Holt County, Neb., using the multitemporal and the all-digital multispectral capability of ERTS-1. A single ERTS-1 image was used to produce a classification map of 81 square miles of Holt County, in which each pixel (smallest element of the ERTS-1 data, about one acre in area) was classified automatically, given a distinctive color, and displayed on film. The use of ERTS-1 data from two successive passes allowed the computer to classify the seven crop types present with better than 90 per cent accuracy. Accurate acreage estimation is important to production estimates since production equals the product of acreage times yield per acre.

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Interpretations of ERTS imagery for three counties in the Nebraska Sand Hills region indicate that major soil associations and attendant range sites can be identified on the basis of vegetation and topography, using spring imagery and snow-enhanced winter imagery. This procedure delineated associations of soils for McPherson County, Neb. The level of generalization is intermediate between county soil association maps and standard soil surveys made by observations of soil profiles and landscapes on the ground.

In some cases, the characteristics interpretable on ERTS data taken when the soil is exposed and minimum vegetation is present are not sufficient for a conclusion on soil associations. The investigator working in the Sand Hills region found that landforms as highlighted by snow cover provided the final information necessary to identify soil associations in ERTS imagery.

Investigators have also reported that ERTS-1 data can be very valuable to forest resource managers. Using multispectral scanner (MSS) imagery, investigators were able to determine the extent and estimate the volume of timber taken through clear-cutting and other timber industry techniques. Other investigators were able to map areas burned by forest fires quickly and more accurately than ever before. They were also able to accurately estimate timber volume in a national forest in a fraction of the time and at one-tenth the cost of previous forest volume surveys of the same area.

In agricultural land use, ERTS-1 has made a significant contribution toward future relief of the drought and famine-stricken Sahel region of Africa. While studying ERTS imagery of the region, ERTS investigators detected a rare area of vegetation within the semi-desert region. The unusual straight lines of the area's boundaries led to the conclusion that the feature was man-made.

On a field trip to the area, investigators discovered that the dark polygonal area was a carefully managed fenced-in ranch, differing noticeably in vegetative cover from the uncontrolled grazing areas outside its fence. The ranch demonstrates that controlled grazing can make it possible for some of the desert areas in the Sahel to be reclaimed for productive use. The findings of this study have been communicated to the affected nations of the region.

Land Use and Mapping

Land use and mapping have become increasingly important as the nation addresses the problems of suburban expansion, urban renewal, slum clearance, highway and transportation planning, environmental quality and energy resources. Several states have recently passed legislation aimed at better management and development of land. These efforts would benefit greatly from a periodic land use inventory.

ERTS-1 has demonstrated a capability to efficiently provide land use information and can be used in several ways to prepare land use and resource maps of large regions. A land use map of Rhode Island, Connecticut and Massachusetts was prepared in a matter of days and was up to date as of the time the observations were made.

Conversely, maps produced by conventional means may be obsolete at the time of printing because of the time required to assemble them. Also, the local nature of conventional means may be obsolete at the time of printing because of the time required to assemble them. Also, the local nature of conventional land use mapping leads to variations in data bases which increase the difficulty of comparison on a national or even statewide basis. ERTS can provide a workable basis for land use classifications and descriptions that are compatible among all states and federal agencies.

Land use inventory information obtained from ERTS can be incorporated into existing state and regional land use information management systems. For example, the states of Michigan, Minnesota, New York and Wisconsin have found that information obtained from ERTS can be used to update their systems. In Wisconsin, where the inventory of wetlands is especially important, it was demonstrated that information from ERTS has strong possibilities for detecting and inventorying wetlands and was found to be more descriptive and accurate than current statewide information sources.

Reg.?

The joint Federal-State Land Use Planning Commission of Alaska (10 state and federal operating agencies) is making excellent use of ERTS land use inventory information. ERTS has made it possible to conduct the state's first large-scale land use inventory and will aid in the selection of 220 million acres of public domain land; identifying and preserving land suited for agriculture; forest management, including assessment of damage by fire and infestation; and pipeline and highway location.

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It has also been demonstrated that ERTS-1 imagery is very useful for map revision,making thematic maps (maps portraying a particular subject) and producing photomaps. The addition of new water bodies on the Virginia state base map is an example.

Photomosaics compiled from ERTS-1 data revealed previously unknown features in Antarctica, including a group of mountains in southern Victoria Land and at the head of Lambert Glacier. Inspection of less than 10 per cent of the imagery available clearly indicates the need for revising the maps of about 1,200 miles of the coastline of Antarctica. Time-dependent features noted on the photomosaics include changes in:

- Coastal configuration
- Position of Burke Island
- Size and position of the Thwaites Iceberg Tongue; its area has increased from 44,200 square kilometers (17,680 square miles) to 71,500 square kilometers (28,600 square miles), and its position has shifted about 8 kilometers (4.8 miles)

An experimental 1:250,000 scale photo image map has demonstrated that National Map Accuracy Standards may be attained with ERTS images at this scale and format. While the capability for the 1:250,000 scale was shown to be within the accuracy of the data, it was decided to make final maps at 1:500,000 for user convenience. A series of these 1:500,000 scale quadrangles is now in production by the U.S. Geological Survey using imagery from ERTS-1. The large area covered by an image enables each quad to be constructed from only a few images. Previously, photomaps at this scale required many aircraft images. The extremely arduous mosaicing and tone matching that was then necessary resulted in prohibitively high costs as well as a time cycle that detracted from the usefulness of the final product. With the real-time advantage of ERTS, a series of photomap products can be produced in a fraction of the time and at a cost that allows frequent new editions.

Water Quality and Resources

To become more efficient in the utilization of available water supplies and to find new sources of water, a system that can observe and monitor large areas of the Earth repetitively and identify and analyze water resources is a necessity. Global estimates of the actual area covered by surface water can be made for the first time with ERTS data, whereas previously only rough estimates were available. By knowing the kinds of water bodies indicative of various physiographic areas, indices of the volume of water available in a particular region can be obtained. By locating surface water area in relation to urban centers, irrigated areas and industrial development, plans can be made for future water resources development. Some of the practical applications of this data that have been identified by ERTS investigators include flood analysis, water management, glacier monitoring and snow cover mapping.

Annual flood losses in the United States frequently exceed $1.5 billion a year. Projections indicate that this cost will continue to rise markedly due to the continued encroachment and development by man on floodplains. In the spring of 1973, streamflow in the Mississippi-Missouri River complex reached the highest flood levels since 1844 in some locations. Before and after views of a portion of the Mississippi River below Memphis, Tenn., taken with the ERTS-1, illustrate the measurements obtainable from the satellite. From these images, it was possible to ascertain very quickly the area covered by water. Mapping of such floods for an entire region can be used in many types of decision-making models, such as where flood relief efforts should be focused, which areas are flood-prone and where flood-control structures are needed.

Because of the strong contrast between water and surrounding surfaces when viewed in the near infrared, surface water is one of the most easily delineated parameters and its area can be easily obtained. The error with which this measurement can be made has been conservatively estimated to ± 5 per cent.

ERTS data have been used to identify small, transient lakes in the Texas High Plains and by the Army Corps of Engineers for surface water surveys in various regions of the U.S.

Numerical water distribution models have been implemented in south Florida that combine the area of surface water obtained from ERTS imagery and the water level obtained from the ERTS data collection platforms. The numerical water distribution models not only calculate the volume of water in previously unmeasurable swampy regions, but also act as inputs to water strategy models concerned with the release of water from one storage area to another.

Nearly 80 per cent of the fresh water on the Earth is contained within glaciers and icecaps. They are important not only as a source of fresh water, but also because of the hazard they can represent. As a result, it is important that the location, movement and extent of glaciers be understood and monitored. Glaciers are readily observed in ERTS imagery.

Several investigators have reported that it is possible to measure the advance of surging glaciers, which can be easily distinguished by their characteristic wiggly-folded moraines, using ERTS-1 imagery. The causes of glacier surges - and why some surge while others do not - are questions of great scientific interest, since this periodic sudden slippage is common to many other phenomena in nature, perhaps even to the mechanism of earthquakes. Also, surging glaciers can advance over large areas and cause devastating floods by blocking and suddenly releasing large quantities of melt-water. During 1972, a surging glacier in the U.S.S.R. caused a 10-meter (33-foot) rise in river level and necessitated the evacuation of a town of 10,000.

A large portion of the runoff in the western United states results from snowmelt. Accurate prediction and management of water coming from snowmelt is very important, and small increases in the accuracy of runoff prediction can mean significant monetary benefits. A single ERTS image covers the Salt Verde Watershed in the Arizona mountains, for example, making unnecessary the constructing of a mosaic of air photos, and permits snowlines to be mapped with more detail than is currently sketched on topographic maps using aircraft. The resulting analysis is now as rapid as that using aircraft data. Eventual computer processing can be expected to reduce this time substantially.

Minerals and Land Resources

ERTS is providing valuable geologic information about the Earth. New structural features, such as faults and fractures, have been identified and areas have been mapped to depict structural, landform and rock-type information.

One important contribution from ERTS-1 has been the identification of previously unknown structural features, particularly long linear faults and fractures. Identification of unknown structures is important because past experience has indicated that metallogenic provinces, oil accumulations and hazards such as earthquake zones are directly related to their existence. For example, very good correlation has been shown between major mining districts in central Colorado and photolinears (primarily faults or fractures) mapped from ERTS imagery. Five of ten target areas (areas with high potential for minerals) identified through interpretation of the photolinear map coincide with major mineral districts. Exploration of the other five areas appears to be warranted.

Another example is the identification of a potential oil-bearing zone in the petroleum province of northern Alaska. A previously unnoticed alignment of many small lakes was identified as a regional lineation which parallels the trend of deflections in magnetic and gravity field contours of the area. Additionally, the outline of a large and small ellipse on the lineation, similar to the domal structures which form oil traps, was observed on the ERTS imagery. These data, with information on nearby formations and sparse seismic profiles, suggest that favorable petroleum reservoir beds may be present.

Scientists of the Eason Oil Company also found that ERTS imagery may be of use in petroleum exploration. Photo-interpretation of ERTS imagery of the Anadarko Basin in western Oklahoma revealed 76 anomalous features (geomorphic, tonal and "hazy" areas). Of the 76 anomalies, 59 correlated with producing oil and gas fields, 11 were known but non-producing structures, and the remaining six could not be correlated with known features. Of 35 "hazy" anomalies, 33 correlated with producing fields or drilled structures. Additional work is required to determine the significance of these anomalies.

A third example is the identification of previously unknown faults which correlate to zones of intense earthquake activity in Alaska. A mosaic of south central Alaska was constructed from 19 ERTS images for this purpose.

An additional area which has benefited from ERTS is rock-type identification. An example is the successful drilling of a shallow water well in a sandstone deposit near Flagstaff, Ariz., and the identification of other such sandstone aquifers which could provide ground water to ranchers in the area. The potential aquifers were identified on digitally enhanced ERTS images based on structural relationships recognized from the ERTS imagery. The city of Flagstaff plans to drill these sites.

Investigators have also used ERTS imagery for constructing geological base maps, and have been able to distinguish features such as roads, bridges, lineations and erroded gullies as narrow as 18 meters (60 feet).

In many cases, intricate lava flows and regional rock types can be accurately mapped, geothermal springs--as small as 2.5 square kilometers (1 square mile) in area--identified, and coastal erosion monitored. This type of information, in conjunction with the geological hazards data available from ERTS, provides excellent input for decision-making in regard to construction sites, nuclear power plant siting, mining, etc.

Marine Resources

The Nation's coastal zone -- beaches and shorelines and their adjacent waters -- constitutes a major marine resource with economic, recreational and social characteristics. The public and private sectors have conflicting interests in, and demands on, this marine resource. Not only is it important to insure its effective utilization and management, but it is also necessary to insure the adoption of measures to protect the beaches and shorelines from natural processes and man's activities that can have adverse effects on them.

ERTS's synoptic view of the coastal zone permits the acquisition of water circulation information that could not be obtained otherwise. Researchers, using the presence of sediment as a natural tracer, are able to infer and map circulation patterns in coastal waters. This type of data has been used to map variations in current circulation patterns and infer along-shore sand transport off the coast of California; to provide information on circulation patterns within the Delaware Bay; and to reveal unexpected circulation patterns in the northern portion of Cook Inlet, Alaska.

Information of this type is useful in several ways: in predicting the dispersal and effects of dumping industrial wastes and sewage within the coastal zone; as an aid in harbor planning and predicting channel dredging areas; and for selecting locations for recreational areas and offshore facilities, such as drilling platforms and power plants. As an example, Delaware is using ERTS data in developing a deployment strategy for equipment to be used in controlling and abating accidental oil spills.

Knowledge of the location and movement of sea ice and icebergs is of considerable interest to the nation's shipping industry. ERTS has demonstrated the feasibility of using multi-spectral imagery to identify ice types, distribution and movement and to observe and measure seasonal events such as ice load development, ice shore patterns, and rate and location of ice break-up. This information is particularly valuable to shippers who need to know which ports are ice free and where shipping lanes are open through the ice. Canada is using ERTS imagery on an operational basis for routing ships through ice-laden waters.

An analytical technique for measuring absolute water depth (bathymetry), based upon the ratios of two MSS channels, has been developed. The technique requires some knowledge of bottom reflectivity, water transparency and surface characteristics. Initial evaluation of the technique indicates it is useful in coastal areas of low to moderate turbidity for depth measurement up to 9 meters (30 feet) and for updating the locations of reefs and shoals on hydrographic charts.

In the application area of living marine resources, the use of ERTS-1 image-density patterns as a potential indicator of fish school location has been demonstrated for one coastal commercial resource, menhaden. Further development of these satellite techniques may yield the only practical method of monitoring and assessing living marine resources on a large scale.

Environment

The major goal of the ERTS-1 investigations in the environment applications area was the collection and evaluation of physical, chemical and biological data as they pertain to the Earth's water and land resources. The major elements that impact the environment include industrial activity; mining operations; agricultural, forestry, and range practices; wildlife; and man himself. These elements interact with each other and, in turn, with land and water resources.

Although it is recognized that activities relevant to the environment appear in other discipline areas, some of the significant results relating to ERTS's ability to remotely monitor and assess environmental conditions related to water quality, land and vegetation quality, wildlife resources and the general environment are summarized here.

The major accomplishments in ERTS-1 water quality investigation include establishing techniques to permit semiquantitative estimates of the content of suspended solids in concentration from 5 to 1000 milligrams per liter (.26-gal.) and chlorophyll in water; the capability of recognizing dispersal patterns of large masses of turbid waters; and the ability to detect large-scale dumpings and outfalls in water bodies. These accomplishments have shown the potential for an operational application in the detection of major pollutant sources and the monitoring of their movement and dispersion in lakes, rivers, bays and oceans.

Investigators have reported studies dealing with land and vegetation quality ranging from the desert environment of southeastern United States to the north slope of Alaska. Major accomplishments reported include the classification of strip-mined areas for both mined acreage and reclaimed regions; the classification of permafrost and vegetation regions of Alaska; the classification and mapping of urban areas; and the monitoring of changes in protected areas (wetlands) due to construction, dredging and filling. The detection of strip mining practices and wetlands changes is a major application ready for demonstration.

In the area of wildlife management, several investigator used ERTS-1 imagery to identify and measure habitat parameters that affect animal species. Under normal population densities, wildlife species are not resolvable on ERTS-1 imagery. However, investigators have been successful in identifying and measuring habitat factors, such as vegetation and water, that have both direct and indirect influences on wildlife populations.

In the past, vegetation maps of certain wildlife habitats have been gross generalizations due to the difficulties of access to remote and sometimes hostile terrain. ERTS not only shows remote areas, but does so synoptically. ERTS maps can show eight to ten vegetation classes, with relatively detailed peripheral boundaries, as compared to former maps of two to four classifications having very generalized boundaries. Adding surface water gives a good map of a habitat.

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Detection of smoke plumes, aircraft contrails, urban haze and atmospheric aerosols has been reported by many investigators. One investigator used ERTS imagery to measure vertical aerosol burden over ocean areas at accuracies estimated at $\pm$ 10 per cent. An image of air pollution over the Great Lakes demonstrated conclusively that air pollution interacts with the meteorology of the area, directly influencing the dynamics of cloud behavior and, in some instances, precipitation.

USER AGENCIES

The following sections were prepared by federal agencies that are using ERTS data in research projects and demonstrations of potential applications for operational use.

U.S. Department of Agriculture

There is a continuing need for improvement in a system which will produce an economically sound remote sensing program that can effectively collect real time data for efficient inventory, protection and management of agricultural and forestry resources. This involves testing the feasibility of using aerospace-acquired data, along with other relevant data, to make accurate predictions of food and fiber resources as well as monitoring changes affecting the total production and quality of these resources and environment.

Since ERTS-B is carrying the same sensors as ERTS-1, the investigators within the agencies of the Department of Agriculture will continue to analyze the remotely sensed data in the form of imagery or from the computer-compatible magnetic tapes. The many possible applications of satellite remote-sensor data have not been used in an operational mode.

ERTS investigators have identified five application areas they feel -- if additional sensors such as thermal infrared were added -- offer the greatest probability of success from the standpoint of technical feasibility and potential value:

- Inventory and monitoring agriculture crops and lands;
- Inventory and monitoring of rangelands;
- Monitoring changes at the urban-rural interface;
- Inventory and monitoring of forests;
- Inventory of habitat for wildlife management.

Inventory and monitoring of these items has proved successful for large areas, or over areas where the variables are not mixed. In order to develop reliable data, it is often necessary in areas where there are small fields or mixed crops, or in forested areas containing a mixture of species and age classes, to supplement satellite systems with data gathered using low-flying aircraft and ground observers. An improvement in the imagery resolution in future satellites will greatly facilitate gathering these data.

In another application, the Department will join with two other federal agencies in an experiment using ERTS-B satellite data which will study the degree to which computer assisted analysis of data acquired from space can contribute to crop forecasting. The purpose is to find out if use of data gathered by spacecraft and analyzed with the aid of computers can improve the timeliness and accuracy of major crop forecasts.

Greater reliability can be obtained with comparison of data taken on several dates. Satellite data has not been available long enough to establish the degree of dependability of these programs in an operational context. Continuity of data from current sensors is desirable for further investigations in the areas mentioned above. However, additional channels (i.e., a thermal sensor) would greatly increase the usefulness and application possibilities of remote sensing data from satellites.

Army Corps of Engineers

ERTS-1 has been invaluable to the U.S. Army Corps of Engineers in developing the ability to effectively use remote sensing technology.

ERTS data has made a significant contribution to many activities such as the National Dam Safety Program; the development of several large area environmental impact statements; coastal studies on the Atlantic and Pacific coasts; and the collection of baseline data for several regional studies. In addition, the data collection system (DCS) capability provided by ERTS has permitted the Corps to establish confidence in satellite data relay for remote collection stations three to five years earlier than could have been expected without ERTS. This can result, assuming continuing availability of a DCS, in savings of millions of dollars over the next decade.

The Corps of Engineers will continue its involvement in the Earth Resources Technology Satellite through the ERTS-2 phase. The Corps will conduct three NASA-funded ERTS-2 investigations.

The Corps of Engineers' New England Division (NED) will receive satellite relayed data collection platform (DCP) data and imagery acquired by ERTS-2. Management of the NED reservoir system requires a wide range of hydrologic information received from ERTS DCS can be utilized by the Reservoir Control Center in NED in the performance of its functions related to the operation of flood control and other multipurpose projects. It is expected that receipt and analysis of ERTS imagery will supplement and improve the interpretation of current NED data sources and data from proposed DCPs. The Corps also expects to assess the operational problems associated with a direct downlink to NED Headquarters.

The Corps of Engineers' San Francisco District will determine the applicability of ERTS-2 data to the coastal planning, engineering and operations mission of the Corps. The California Coast Nearshore Processes Study is concerned with the analysis and modeling of nearshore processes for use in protecting and developing the California coast. Primary objectives are analyses of sediment transport, nearshore currents, riverine discharge and estuarine flushing. Simultaneous aircraft and sea truth surveys will collect data during ERTS-2 overflights. The information will be studied utilizing sophisticated data processing techniques. Findings are expected to benefit coastal planners and engineers in developing the California coast for pleasure and commerce. Benefits will primarily come as reductions in engineering time, lower maintenance costs, and in less severe storm damage due to more predictable forecasts of coastal dynamics by coastal engineers.

The Corps of Engineers Construction Engineering Research Laboratory will carry out an ERTS-2 project in conjunction with a long-range, funded, environmental research program to determine the environmental impacts caused by the construction and operation of an inland reservoir. Satellite and high-level aerial imagery will theoretically provide an economical method to record and store environmental data for analysis to determine what environmental changes have occurred as a result of a reservoir project. Aircraft and ERTS imagery will be analyzed, coded and placed in a digital mapping routine. Ground truth data will be used to test the accuracy of the interpretation and the nature of the detected changes. The use of satellite imagery may provide an economic, rapid method to collect environmental data for predicting impacts of inland reservoir projects.

The Corps will also serve as an adviser to the ERTS project on nine other ERTS-2 investigations to be carried out by other agencies.

Department of Commerce

The Department of Commerce, through its National Oceanic and Atmospheric Administration (NOAA),will continue to examine possible applications of ERTS data to its products and services.

NOAA develops and carries out programs to assure that the ocean environment and its resources are wisely used in a balanced way to enable their development as well as conservation for the national economic and environmental well-being.

NOAA is also charged with developing and operating systems to monitor and predict environmental conditions such as weather, ocean and solar events, and with exploring the feasibility of beneficial modification of environmental conditions and the understanding of consequences of inadvertent modification.

As with ERTS-1, NOAA scientists look to data from the new satellite to provide a high-resolution look at the Earth's oceans.

ERTS-2 should provide data which may be used in research on water mass classification, including living marine resources, ocean dumping monitoring, measurement of internal waves, hydrology and aeronautical charting.

Water mass classification programs are needed to support the agency's Marine Ecosystems Analysis (MESA) program, which includes water quality monitoring and current boundary identification. Through the data obtained from ERTS, scientists can monitor patterns of energy transmission and reflection in estuaries and bays and mark zones where cold water meets warm, fresh water meets salt, and polluted water meets clear. Repeated observations can be used to identify long-term pollution trends, and such short-term ecological catstrophes as major oil spills.

In the area of research on living marine resources, ERTS data should prove valuable for fisheries investigations such as a program relating shrimp distribution to coastal turbidity, another relating the distributing of tuna and surface temperatures, and still another on the effects of offshore oil exploitation, deep water dumping, and offshore power plants on living marine resources.

Under a hydrology research program, NOAA scientists will attempt to determine not only the extent of snow cover but also the condition of the snow, especially whether it is melting or not, by analyzing the spectral radiance of the snow surfaces. During the summer, selected test sites will be monitored to measure the effect of soil moisture on spectral reflectance.

Of particular interest to NOAA oceanographers is research on internal waves and surface dynamics on the continental shelf and open ocean. Internal waves are of interest because of their effects on bottom sediment transport, mixing processes, and propagation of sound in the sea. Sea waves are modified by bottom topography, and viewing these waves with ERTS capabilities may provide additional insight into these processes.

A NOAA program which now uses ERTS data on a near-operational basis is aeronautical charting. ERTS images and other satellite derived data are used to update and revise mapping of water features on some visual aeronautical charts. As follow-on ERTS experiments provide greater resolution, the data will be useful in providing information on population boundaries, interlacing transportation systems, and the accompanying thin lines of population.

It is important to update these features in order to comply with certain federal Aviation Administration safety regulations, and this updating will be mandatory for the expected future increases in nighttime visual flying. NOAA is using the ERTS and other data for these experimental programs in cooperation with the U.S. Geological Survey.

The Bureau of the Census is another element of the Department of Commerce that anticipates major use of ERTS data. To meet its needs to define urbanized areas within the nation's Standardized Metropolitan Statistical Areas, cooperative research by the Bureau and the U.S. Geological Survey indicates that urbanized areas can be delineated with a high degree of accuracy from high altitude and space photography. It is expected that similar results can be obtained from multispectral imagery obtained from ERTS. The Bureau proposes to investigate this technique for a number of Census programs.

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Interior Department

The Interior Department is manager of the nation's natural resources and its principal conservation agency. It has been deeply involved in the ERTS program since its inception.

The Interior Department mainly through its U.S. Geological Survey (USGS), helped conceive and plan the ERTS program, and is the largest single operational user of ERTS data and images. The USGS manages Interior's Earth Resources Observation Systems (EROS) program and the EROS Data Center at Sioux Falls, S.D., the largest repository of remote sensing data in the world.

Interior began intensive testing of the applications of aircraft and satellite remote sensing to natural resources and environmental studies in 1964, and established the EROS program in 1966, six years before ERTS-1 was launched. A prime mover behind this early effort was the late Dr. William T. Pecora, Director of the Geological Survey and later Under Secretary of the Interior.

Because of Pecora's genius and vision in conceiving a program for remote sensing of Earth's resources and environment by satellites, the Interior Department and NASA, after his death, established the William T. Pecora Award to honor outstanding contributions toward understanding Earth and its atmosphere by means of remote sensing from satellites. William A. Fischer, EROS senior scientist with the USGS, received the first Pecora Award last July 12 at the dedication of the Survey's National Center in Reston, Va.

The EROS program, headed by Dr. John M. DeNoyer, is aimed at applying ERTS images and other aircraft and satellite remote sensing data for Earth resources and environmental purposes such as monitoring strip mining, helping locate new oil and mineral deposits, and mapping floods and changes in land use. EROS scientists seek to encourage use of remote sensing by developing new remote sensing techniques, capabilities and products; providing necessary training; and encouraging development of operational use programs in the Interior Department and elsewhere in the public and private sectors, both domestic and foreign.

The EROS Data Center, located on a 315-acre site 14 miles northeast of Sioux Falls, is the principal public outlet for ERTS images and other satellite and aircraft remote sensing data. Copies of all ERTS images are sent by NASA's Goddard Space Flight Center to the EROS Data Center, where they are catalogued and stored along with millions of other satellite and aircraft views of Earth's surface. All these images are available for purchase by anyone in the world at nominal cost in a variety of sizes and forms, including prints, negatives, transparencies and, in some cases, computer tapes.

To date more than five million images, including more than 476,000 ERTS images, have been placed on file in the Data Center which is filling orders for more than 20,000 ERTS images a month.

The ERTS program is international in scope. Researchers and other users from 111 foreign nations have been in contact with the EROS Data Center, either to order images or seek information. Scientists in a number of these nations are using ERTS images obtained from the Data Center to conduct research and help carry out operational programs in their own countries. EROS scientists themselves have traveled to other nations such as Iceland, Iran, Kenya, Turkey, Bolivia and Australia to help conduct research and conduct training courses and seminars in remote sensing.

The Applications Assistance Branch of the Data Center helps users learn how to interpret ERTS images, extract useful information and apply such knowledge to operational problems both at home and abroad. So far, the Data Center has provided assistance to more than 1,300 technical visitors and its six regional assistance facilities have provided help to another 7,000. To date, 115 American scientists and technicians and 84 from foreign nations have completed formal training courses and seminars at the Data Center, and 500 other U.S. users have completed training courses at the regional assistance facilities.

EROS scientists and scientists from the USGS and other Interior Department bureaus are using ERTS-1 images and data, and plan to use ERTS-2, for various research projects and operational programs. Interior had 45 ERTS-1 research projects approved by NASA and conducted a number of additional projects on its own. NASA has approved nine Interior investigations using ERTS-2 data; however, EROS will sponsor, through the USGS and other Interior bureaus, at least 20 additional ERTS-2 research projects.

The main thrust of Interior's ERTS-1 investigations was toward basic research and feasibility studies: finding out just what could be done with ERTS images and data to help man better manage Earth's resources and protect its environment. With the launch of ERTS-2, the emphasis will be shifting more toward applying ERTS data to operational programs, especially those that require repetitive coverage and prompt delivery of data, such as assessing the quality and quantity of forage on rangelands and the distribution of snow cover in water and reservoir management districts. With shortages of energy and minerals still facing the nation, more emphasis will be placed on using ERTS to help find new oil and gas deposits and other sources of energy and minerals.

The USGS has already incorporated ERTS data into its operational programs to support mineral, energy and land resources projects; to support ERTS data collection platforms (DCPs) to collected hydrologic data; and for publishing ERTS image maps and mosaics of areas within the U.S. and part of its Antarctic mapping program. Experimental land use maps, produced directly from ERTS computer compatible tapes, have been prepared for several areas in the U.S.

EROS officials outlined a broad, five-point thrust for use of ERTS-2 data:

- Continuing basic research in cases, such as studying the growth of cities, where data over longer periods of time are needed;

- Studying the dynamic conditions on Earth, such as changes in reservoir levels, distribution of vegetation and changes in landscape features due to strip mining;

- Detecting geological and geohydrologic features that are intermittently visible;

- More use of digital tapes and direct processing of original ERTS data rather than using actual images. EROS scientists say up to 50 per cent of the information recorded by ERTS is lost when the data are converted from the original magnetic tape to image format;

- Improve delivery time of ERTS data to users.

Specific examples of the use of ERTS-1 data by agencies of the Interior Department include:

Oil, Mineral Deposits: USGS geologists demonstrated that ERTS images can record extensions of known faults, lineaments and other linear and circular patterns, often not visible on aerial photographs, that could be clues to possible oil and mineral deposits. One previously unknown series of such surface features, too large to show up on aerial photography, was spotted on an ERTS image of northern Alaska, indicating a target area for further exploration of oil and gas deposits. This capability of ERTS could be of crucial importance in helping to increase the world's supply of energy and minerals.

Flood Mapping: Devastating floods on some 3,200 kilometers (2,000 miles) of the Mississippi River and its tributaries -- including the Ohio, White, Yazoo and Ouachita rivers -- in the spring of 1973 were imaged by ERTS-1. USGS hydrologists confirmed on the Mississippi flood a discovery by Iowa state hydrologists that they could measure the maximum extent of flooding from ERTS images taken after water started to recede. ERTS-1 also imaged floods on the Connecticut river in New England, and on the Indus and Jhelem rivers in Pakistan later in 1973. Flood mapping by ERTS can be useful in flood control, disaster relief, flood insurance and water resources assessment and management programs.

Tornado Damage: ERTS-1 recorded the destructive path of a tornado which cut a swath through the Bankhead National Forest and adjacent wooded areas of northern Alabama and then leveled the town Guin, Ala., on April 3, 1974. The USGS and Army Corps of Engineers scientists who spotted the 89.4-km (57-mi.) long swath on an ERTS image said their findings show that ERTS can provide regional views of areas of tornado destruction to aid in damage assessment and planning for recovery operations.

Volcanoes: A prototype global volcano surveillance system was established by the USGS using the data collection system (DCS) on ERTS-1. Automatic monitors installed on 16 volcanoes in North and Central America, Iceland and Hawaii detect early warning signs such as ground tilt and/or weak swarms of Earth tremors that might precede an eruption by days or even weeks, months or years. This is relayed via ERTS to ground receiving stations six to ten times daily for transmittal within 90 minutes to the USGS's National Center for Earthquake Research at Menlo Park, Calif. The success of the prototype system clearly demonstrates the technological and economic feasibility of building a global volcano surveillance system using the ERTS DCS relay capability.

Lineaments and Faults: USGS geologists have used ERTS images to map surface lineaments and extensions of known fault lines that could indicate the location of possible earthquake activity in the future. Some of these lines were too large or faint to be seen on conventional aerial photographs. Knowing where lines are can help in siting nuclear power plants and other facilities in areas where they are not likely to be damaged by earthquakes.

<u>Snow Cover</u>: Hydrologists from the USGS have shown that ERTS can map and monitor variations in snow cover extent in hydroelectric power reservoir watersheds in the Pacific Northwest. This capability can give reservoir managers more accurate information on the amount of snow melt runoff, enabling them to more efficiently allocate the available water between electric power generation, irrigation, flood control and other needs.

<u>Cartography</u>: The USGS has concluded that ERTS has applications to cartography in making and revising maps at scales of 1:250,000 or smaller (those covering larger areas). For larger scale maps (those showing smaller areas), ERTS can monitor changes and indicate where revisions should be made. One ERTS image covers the same area as 1,000 aerial photographs. These cost substantially more to acquire and usually are several years old. In addition to showing where existing maps should be revised, ERTS-1 images and image mosaics have been used as map bases, with names of cultural and other features overprinted on them. The USGS has prepared mosaics of New Jersey, Arizona and Florida from ERTS images. Survey topographers say the complete global and repetitive coverage of ERTS opens the way for automated regional scale, planimetric mapping of the Earth.

<u>Antarctica</u>: ERTS has special cartographic applications in Antarctica and other remote and poorly mapped parts of the world. USGS scientists have used ERTS to map and monitor changes in glaciers, ice tongues and ice shelves along the Antarctic coast. ERTS images have shown the need for substantial revisions in existing maps of Antarctica, and have disclosed unknown mountains and other geographic features in the interior of the continent.

<u>Iceland</u>: USGS has cooperated with Icelandic scientists to study the use of ERTS to map and monitor changes in such things as snow cover, glaciers and grazing lands in Iceland. New lava flows and ash falls and snow melt patterns, as well as altered ground in some geothermal areas, could be delineated.

<u>Glaciers</u>: ERTS-1 has been used by USGS scientists to monitor "galloping" or surging glaciers -- those which periodically move up to four feet an hour instead of the normal flow of only a few inches a day. Most glaciers are in remote areas. But surging ones can cause devastating floods downstream when they block and then suddenly release large quantities of melt water. ERTS-1 has monitored surging glaciers in Alaska, Canada, Iceland and the U.S.S.R. USGS scientists said ERTS also may some day be used to monitor glaciers as potential sources of water supply.

Sea Ice: Scientists from the USGS and other organizations have used ERTS to study the dynamics and monitor the movement of ice islands and sea ice in the Beaufort Sea and other areas of the Arctic. This type of information will be needed if the oil and mineral resources of the Arctic are to be developed and ships operated in Arctic waters. Another future benefit might be to tow icebergs from the Antarctic to selected sites for use as a water supply or as a "heatsink" for cooling water heated by power generators.

Ground Water: Hydrologists for the USGS have shown that ERTS images can detect surface features and changes that could indicate the presence of underground water. Some of these surface signs include types and distribution of vegetation, differences in ice cover on streams, varying types of soils and differences in soil moisture and snow melt. Thus ERTS can be used as a tool for exploration of ground water as well as for monitoring and managing ground water resources.

Wetlands: USGS hydrologists have used ERTS-1 to map and classify Chesapeake Bay and other Atlantic coastal wetlands, and to identify wetland-dryland boundaries, major vegetation types and changes caused by man's activities. Monitoring of wetlands is essential for proper management and conservation of these areas and the wildlife they support. At relatively low cost, ERTS can provide repetitive information for updating maps of coastal areas undergoing rapid change.

Everglades: Hydrologists from the USGS have developed a plan to use ERTS in helping manage the water resources of the Everglades region of Florida, and in so doing to preserve the ecology of the area. Under the plan, ERTS images will be used to map the areal extent of surface water in the Everglades region, and ground sensor data on the depth of the water will be relayed by the ERTS data collection system (DCS) to ground receiving stations for transmittal to the Geological Survey office in Miami. Hydrologists then can determine the volume of water in the area and regulate its flow for maximum benefits.

Thematic Mapping: USGS and other scientists have developed techniques for thematic extraction of certain features from ERTS images. For example, areas covered by forests were extracted from an ERTS mosaic of Alabama. Thematic mapping of the Dismal Swamp in Virginia and North Carolina delineated areas covered by deciduous trees, evergreens and farm fields, and even by a single species of tree -- the Atlantic white cedar. Producing maps of and monitoring changes in such things as vegetation, water and snow cover can be done quicker and cheaper with ERTS than with conventional methods.

South America: USGS scientists analyzed ERTS-1 images of a remote mountainous area covering parts of Peru, Bolivia, Chile and Argentina for geological and hydrological data. The ERTS images revealed a number of unknown lakes, salt basins, volcanic craters and other geologic features that had not been on existing maps, and disclosed that existing maps had placed some features in the wrong locations. The USGS scientists concluded that ERTS can provide an invaluable data base for Earth resources surveys and development in large and relatively undeveloped regions.

Iran: A USGS scientist used ERTS-1 to inventory playa (closed basin) lakes in Iran, in which water levels and volume vary widely with the seasons. He concluded that large amounts of water in the shallow playas are lost to evaporation each year, and that more could be retained for agricultural, industrial and other human uses if larger, deeper reservoirs were built. He also picked out a route for a modern road across an undeveloped desert area of Iran that is now impassable during part of the year. Iranian officials now are considering building the highway.

Yellowstone Park: ERTS-1 images were used to map dynamic conditions in Yellowstone Park, the oldest national park in the world and largest in the U.S. Researchers for the U.S. Geological Survey showed that ERTS can monitor such things as range conditions, insect infestation of forest, snow cover and wildlife habitat conditions in the more than two million acre park. The National Park Service envisions using ERTS data to assist in future planning, design and development in Yellowstone, as well as analyzing the environmental impact of development.

Smoky Mountain Park: The National Park Service used ERTS-1 images to help inventory the resources of the Great Smoky Mountains National Park in Tennessee and North Carolina and a 13-county region surrounding the park. This inventory is now forming the basis for the new master plan and resources management plan for the park.

Archaeology: National Park Service scientists used ERTS-1 to help solve the mystery of why Pueblo Indians of the 10th and 11th centuries built an extensive system of carefully engineered roads in the Chaco Canyon area of New Mexico, even though they had not discovered the wheel nor did they use large draft animals to transport materials. By comparing the regional relationship of environmental features on ERTS images to previously mapped cultural features and archaeological artifacts, the NPS scientists concluded that the roads led to areas outside the Chaco Canyon where the Indians could hunt, fish, cut wood and gather raw materials for making pottery, tools and other objects.

Indian Reservations: The Bureau of Indian Affairs and the Quinault and Colville Indian Reservations in Washington and the Warm Springs Indian Reservation in Oregon used ERTS-1 to inventory and monitor forests on the reservations. ERTS differentiated between major areas of recent clear cutting, conifer old growth, conifer second growth and hardwood timber. This information will enable the Indian tribes to better manage their forest resources.

Forest Fires: ERTS-1 recorded a forest fire in progress in northern Alaska. The Bureau of Land Management said ERTS could be useful in showing the timber and other resources burned in forest fires. ERTS also can monitor the rate of regrowth of previously burned areas.

Alaska Native Lands: ERTS-1 images were used in preparing resource maps of Alaska to aid native corporations and villages in selecting lands under the Alaska Native Land Claims program. Bureau of Indian Affairs officials said the ERTS images delineated areas of 11 different types of forests and other vegetation cover, and gave some clues of which areas might or might not have mineral resources.

Air Pollution: The Bureau of Mines used ERTS-1 to detect the source of air pollution originating from coal-fired power plants in parts of Pennsylvania, West Virginia and Ohio. Researchers concluded that ERTS can spot the larger smoke plumes if the images are processed to provide contrast between the smoke and the Earth's surface.

Forage: The Bureau of Land Management (BLM) uses ERTS to monitor forage conditions on federal grazing lands in the western states, where the growing season often is short in some desert areas and livestock operations are highly speculative. Livestock operators normally graze cattle only in good forage years, purchasing young cattle, often in Mexico, for fattening on the U.S. public lands. Operators who guess wrong about the season's forage conditions can go broke, and those who wait too long for forage conditions to "prove out" must pay higher prices for cattle and face a shorter grazing season. ERTS enables the BLM and livestock operators to make earlier and more accurate estimates of forage conditions.

Colorado River: The Bureau of Reclamation is using ERTS data to produce land use maps to monitor changes along portions of the Colorado River as part of a wider study of natural resources in the area. This will enable the Bureau to make continuing up-to-date determinations of irrigation water use in the Colorado River BAsin and will likely lead to similar operations by the Bureau in other regions.

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Colorado River Lineament: ERTS-1 images of the Lower Colorado River revealed a major surface lineament which the Bureau of Reclamation said may be an ancient and obscured fault that is in line with the Gila River in Arizona. The Bureau said its findings may be significant in relation to salinity control problems and the geothermal resources development potential in the area.

Project Skywater: Project Skywater is the Bureau of Reclamation's cloud seeding, weather modification research program. Seven data collection stations (DCSs) placed high in isolated areas of the San Juan Mountains of Colorado that experience severe winter weather transmit weather and snow condition data to ERTS-1 for relay to a computer in Denver. Skywater managers then use this data to determine how much additional precipitation they will try to produce through cloud seeding. When spring snows raised flood threats in 1973, Project Skywater suspended cloud seeding in a decision based in part on timely information supplied by the ERTS DCS system.

Rio Grande: The Bureau of Reclamation is using ERTS-1 data on the Rio Grande Regional Environmental Project in New Mexico and Texas to provide an information base for regional planning decisions. ERTS is being used to help determine crop species, vigor of vegetation, land use, mineral and water resources and cultural features.

Rights-of-Way: The Bureau of Land Management is using ERTS images to help select right-of-way corridors for new pipelines, power lines and highways through Federal lands managed by the BLM. ERTS gives BLM a broad view to help it select the best routes to preserve the ecological balance and the environment, and to avoid such things as developed, hazardous and natural beauty areas.

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Migratory Waterfowl: The Fish and Wildlife Service has used ERTS-1 to inventory and monitor wetland breeding grounds of migratory waterfowl. Annual variations in habitat quality greatly influence annual production of these ducks, geese, swans and other wild waterfowl. Surveys of lakes, ponds and other wild waterfowl nesting areas enable resource administrators to estimate the annual waterfowl production. They then can set hunting regulations, seasons, bag and possession limits and other policies based on the estimated population of birds for the season.

Fish: The Fish and Wildlife Service is studying a plan for using ERTS to inventory small lakes, ponds and other water impoundments in the midwestern states. This information would be helpful to fishery managers in allocating their hatchery products and in making other management decisions. Fishery managers now use often out-of-date aerial photographs to survey small water impoundments. ERTS can do the same job more quickly and at less cost.

Environmental Impact Statements: ERTS-1 images are being used by the BLM and other agencies in preparing the environmental impact statements now required for major projects such as construction of the Trans-Alaska Pipeline. ERTS can give an overall view of an area, as well as ~~continue to~~ monitor it.

Strip Mining: The BLM is using the data collection system on ERTS-1 to acquire base line data on ground water, information that is needed prior to strip mining operations on federal lands. By acquiring this information and continuing to monitor ground water supplies, the BLM can assure the continued quality of water during mining operations.

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